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A

Thesis

Presented to the Faculty of

The University of Texas Graduate School of Biomedical Sciences

at San Antonio

in Partial Fulfillment

of the Requirements for the Degree of

MASTER OF SCIENCE IN NURSING

By

Margaret Mary Walsh, BSN

San Antonio, Texas

May, 1998

THERMAL ENVIRONMENT OF LITTER POSITIONS AND HUMAN RESPONSES ONBOARD HERCULES C-130 AIRCRAFT

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THERMAL ENVIRONMENT OF LITTER POSITIONS AND HUMAN RESPONSES ON BOARD HERCULES C-130 AIRCRAFT

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This non-experimental, descriptive correlational research study examined the thermal environment of litter positions and human responses onboard the Hercules C-130 aircraft. The C-130 aircraft is a cargo aircraft that can be configured to transport patients. Thermal stress is one of eight stresses of flight patients experience in the airborne environment. The study measured ambient air temperature, air flow, perception of thermal environment, perception of thermal comfort, tympanic temperature and skin temperature. Measurements were obtained preflight, post flight and every fifteen minutes inflight.

Thirty-four aeromedical evacuation crewmembers participated as subjects on ten flights from December 1997 to March 1998. Subjects were placed on litters and randomly assigned to four litter locations: front/top, front/bottom, back/top, and back/bottom. Findings showed preflight ambient air temperature was low but rapidly increased and stabilized inflight. No consistent significant difference of ambient air temperature or air flow were found between litter positions. Thermal and comfort perception results identified significance between litter positions were front/top litter felt warmer and more comfortable than the back/bottom litter position. Tympanic temperature readings while low were consistent through flight without significance between litter positions. Skin temperature, however was significantly different between litter positions. Skin temperature for subjects in the front/top position increased and the skin temperature for the subjects in the back/bottom decreased. Air temperature was significantly correlated with thermal perception, tympanic and skin temperature. Air flow was significantly correlated with thermal perception.

Findings suggest that patients in the back/bottom litter position were more challenged by the thermal environment than patients in other litter positions. Healthy subjects in this study did not experience difficulty maintaining a stable core temperature. Yet, a compromised patient combating the other stresses of flight may not be so successful. This study can heighten flight nurse's awareness to thermal concerns, assist to determine appropriate litter placement, and anticipate thermal problems to optimize patient care in this challenging environment.

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I INTRODUCTION

Overview of Problem Area

The flight environment is one environment particularly stressful for humans. There are eight identified stresses of flight: decreased partial pressure of oxygen, increased barometric pressure, decreased humidity, variation in temperature, noise, vibrations, g forces and fatigue (Freitag-Hagney & Feagan, 1991). These stresses can further compromise already stressed patients moved in the flight environment. The military routinely transports patients by fixed wing aircraft exposing them to flight stresses. Flight nurses have observed that temperature variations are commonly experienced inflight; however, specific descriptions of thermal variations are not available. Variation in temperature is one stress of flight that a nurse can independently manipulate, decreasing stress on patients. Thus, additional information regarding thermal stress, thermal variation, and patients' responses to variations within the cargo compartment is required.

Aeromedical transportation of a large number of patients occurred in World War II utilizing large fixed wing aircraft. The Korean and Vietnam conflicts established helicopter support for short distance transfers and fixed wing aircraft for moving a large number of patients long distances (Sheehy, 1995). The military continues to transport patients on military cargo aircraft, primarily the Starlifter, C-141 and the Hercules, C-130. Hercules C-130 is a tactical aircraft utilized in contingency operations. Traditional war plans deploy large numbers of soldiers accompanied by hospitals with an array of medical support. In this scenario large numbers of patients receive initial treatment and are stabilized then transported by cargo aircraft. Desert Storm is an example of traditional deployment. The

C-130 was used for patient movement extensively within the theater of operation that continues in the region. Recent global changes have altered perceived threats to the United States resulting in a down sizing of military forces. Such reorganization has not decreased the demand for aeromedical transport as the number of humanitarian missions world wide has increased. Humanitarian missions are primarily staged in remote areas devoid of local medical support. Typically, a limited number of personnel with minimal medical support are deployed for humanitarian missions demanding heavy reliance on aeromedical transportation for medical care of personnel. The C-130 was used exclusively in Bosnia-Herzegovina and Hungary during Operation Joint Endeavor. Furthermore, the anticipated aeromedical evacuation population changed from transport of stable patients who have received medical treatment to critical patients enroute for treatment. Critical care air transport teams were created to aid inflight critical care for acutely ill patients. The stresses of flight posses a significant burden on the critically ill patient. Variation in the thermal environment is one stress nurses can manipulate. A greater understanding of the flight environment and its effects on humans during transport must be obtained to optimize care for patients.

At altitude, one stress of flight, a cold thermal environment, is of principal concern and one nursing personnel can directly manipulate. As altitude increases, the ambient temperature decreases an average of 2 degrees Celsius (°C) for every 1000 feet (Blumen, Abernethy, & Dunne, 1992). Thus, the potential for accidental hypothermia is present. Hypothermia is defined as a core temperature below 35°C (Gentilello, 1995). Mortality of hypothermic trauma patients is significantly higher than those who remain warm (Jurkovich,

Greiser, Luterman, & Curreri, 1987). Hypothermia increases metabolic demand for oxygen up to 400% above normal requirements that may profoundly impact aeromedical patients (Dennison, 1995). Such an increased oxygen demand on a compromised patient, who must also combat other stresses of flight, are potentially severe. The C-130 is a cargo aircraft easily configured for aeromedical evacuation of patients. The C-130 is a pressurized aircraft, and there is an attempt to control the temperature. However, it is cold in certain areas of the aircraft. Air ducts descend from the ceiling and ambient air temperature varies within the cabin. Furthermore, inflight nursing care of hypothermic patients is based on anecdotal reports (Freitag-Hagney & Feagan, 1991). It is evident nurses need to take action to prevent hypothermia.

Purpose of Study

The purpose of this study is to describe the inflight thermal environment of four litter position areas of the cabin as well as human temperature and thermal perception and comfort responses in the litter positions onboard the Hercules C-130 aircraft. The results of this study can significantly affect inflight nursing care by illustrating the thermal environment and its effect on patients transported on cargo aircraft. In addition to inflight care, the results of this study can determine the best placement for the most seriously ill and those patients who are most prone to hypothermia.

Study Questions

1.) To what extent do ambient air temperature and air flow at four litter positions change over time during aeromedical evacuation in a C-130?

2.) Are there differences in average ambient air temperature and air flow at each litter position in different locations within the cargo compartment of a C-130 during aeromedical evacuation?

3.) To what extent do core temperature, skin temperature, thermal perception and thermal comfort of individuals in litter positions change over time during aeromedical evacuation in a C-130?

4.) What is the relationship between litter ambient air temperature and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

5.) What is the relationship between litter air flow and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

Operational Definitions

1.) Ambient air temperature and air flow are defined by a single instrument the Davis® Instruments hot wire thermo-anemometer model 407123. For the purpose of this study, ambient air temperature is the degree Celsius the nearest 0.1°C as measured by a Davis instrument Model 407123. Air flow is measured to 0.1 meters per second (m/s). For this study, ambient air temperature and air flow measurements were obtained in the center of each litter, above subject's hips, and twelve inches above the litter.

2.) A litter is a stretcher made of canvas used to move injured. Litter position is defined as the location of the litter onboard the aircraft as described in Air Mobility Command

Regulation 55-47 and noted on Air Force Form 3905 (See Appendix A). Standard aeromedical configurations were used. Peacetime litter configuration of four litter positions per center stanchions will be used for this research study. The eight litters to be studied are the highest or fourth position, and lowest or first litter position in A, B, G, and H tiers (See Appendix A).

3.) A Hercules C-130 tactical aircraft is one flown and maintained by the United States Air Force. Tactical aircraft are involved in military operations focused on the forward deployment of force to overcome the enemy. All aircraft models currently in use are acceptable for this study and include models A-H.

4.) For this study, core temperature is measured by ProPaq® 106EL employing a tympanic temperature sensor at 0.1°C degree precision. Skin temperature (T) is calculated as: 0.35 (T chest + T bicep) + 0.15 (T thigh + T calf) (Mitchell & Wyndham, 1969). ProPaq® 106EL skin surface temperature probes will obtain skin temperature measurements to nearest 0.1°C at each location.

5). For this study, thermal perception is an individual's cognitive assessment of the immediate environment and assigning a value indicating the degree of warmth or coldness the environment possesses. Thermal comfort is an individual's cognitive assessment of the environmental temperature and indication of that assessment on a visual analog scale. For the purposes of this study, thermal perception and thermal comfort are measured utilizing a visual analog for thermal and comfort perceptions scales (See Appendix B). Thermal perception ranges from hot opposite from cold on a ten centimeter line. Comfort perception

ranges from intense discomfort opposite from extreme comfort on a ten centimeter line. Thermal perception and comfort perception are measured to the nearest millimeter to obtain a numerical score. Regarding thermal perception cold = 0 and hot = 10.

Assumptions

This study has three broad assumptions. First, the environment and humans are each dynamic systems. Second, the environment and humans interact with one another. Finally, the environment affects humans, and humans can affect the environment. Specific assumptions for this research study are as follows:

1.) The stresses of flight that are partial pressure of oxygen, barometric pressure, humidity, noise, vibration, g forces and fatigue do not significantly vary between litter positions within the cargo compartment of the C-130.

2.) The subjects to participate in the study do not have any medical problems that impair sensing and responding to the environment. Furthermore, participants meet minimum fitness standards as well as limits to body fat measurements.

3.) Instruments obtaining temperature, air flow, thermal perception and thermal comfort measurements within the research study measure what they proport to measure.

II REVIEW OF LITERATURE

Theoretical Framework

Humans are homeotherms. Like all mammals humans regulate their internal body temperature within a narrow range regardless of extreme environmental conditions. Heat is exchanged with the environment by four mechanisms: radiation, conduction, convection and evaporation. Thermal energy in radiation passes through air and space from warm to cool objects in the absent of direct contact. Heat transfer in conduction occurs when the skin contacts an object possessing a different temperature and heat is exchanged. In convection the rate of movement is an essential component as heat is lost or gained when air or liquid moves over an object. Heat loss by evaporation occurs when skin or mucous membranes lose water to the surrounding area. Evaporation is facilitated by low humidity, high environmental temperature and high air current velocity (Holtzclaw, 1990). Over the course of a flight, a decrease in cabin humidity occurs. Inflight environmental temperature and air flow are predicted to stabilize at some point once cruising altitude is obtained.

Heat is the key to maintaining thermal balance. Heat is produced in all body tissues by metabolic processes, friction of circulatory blood, and contracting muscles (Holtzclaw, 1992). Metabolic processes are affected by the following: age, sex, height, weight, body surface area, growth, pregnancy, infection or other diseases, body temperature, ingestion of food, prolonged change in food intake, muscular activity, emotional state, sleep, environmental temperature and hormone levels. Muscle activity is the most significant factor in increasing the metabolic rate (Vander, Sherman, & Luciano, 1994). Heat is constantly moving through molecules along a gradient from warmer areas to cooler areas.

In the body, heat moves by conduction through tissue and convection utilizing circulatory blood and a countercurrent exchange. Heat movement by conduction is dependent on tissue area and the distance tissue is from the heat source, typically circulating blood (Holtzclaw, 1990). Heat moved by convection is dependent on rate of blood flow and the temperature difference between blood and surrounding tissue. Heat loss from the body occurs only from tissues in contact with the environment - primarily the skin with small amount from the respiratory tract. Heat distribution of the body can be divided into a core and shell. The core includes the head and vital trunk organs, while the shell encompasses the periphery. The body varies shell thickness that is in contact with the environment to maintain core temperature. As a result, the shell temperature is not regulated within the narrow core temperature limits. Even though thermoregulatory responses directly affect shell temperature, it is dependent on environment and body heat balance (Wenger, 1996).

Thermal balance is maintained by an elaborate regulatory system balancing heat generation, conservation and loss from the body. The regulatory system has three components: 1) receptors, heterogeneously distributed throughout the body, 2) ascending and descending central information processing mechanisms to compare the integrated input with a thermostatic reference range, and 3) effector mechanisms, spatially distributed to initiate compensatory responses to correct deviations (Holtzclaw, 1992). The receptors are central or peripheral. Central receptors monitor core organ temperatures. Peripheral receptors, located in the skin, sense warm temperatures between 30-43 °C and cold temperatures between 20-35 °C. Central receptors supply negative feedback in this system

while peripheral receptors provide feedforward information for thermal perception and behavior responses (Vander et al., 1994). Neuronal structures in the hypothalamus thermostatically regulate thermal balance. Other thermoregulatory structures exist in the central nervous system, particularly in the brain stem and spinal cord, and are of importance to lower species of mammals. In humans, thermoregulatory activities appear to be inhibited by hypothalamic thermoregulatory centers. Thermosensory neurons in the hypothalamus sense circulating blood temperature, and impulses from the periphery are transmitted via spinal tracts to the preoptic anterior region of the hypothalamus. The summated signals from the periphery, reticular formation, and central nervous system are integrated then relayed to the preoptic area of the hypothalamus located ventral to the anterior commissure. This region functions as a thermostatic comparator by detecting deviations above or below the acceptable set point range and initiating cooling or warming responses to restore optimum temperatures. The set point temperature range is defended by physiologic responses to optimize an individual's cellular metabolism and neurotransmission. The set point establishes the body temperature, the net difference between heat production and heat loss, and is variable by location and constantly fluctuating (Holtzclaw, 1992). The effector mechanisms adjust skin blood supply determining shell thickness. For example, in a cool environment vasoconstriction limits skin blood flow to increases the thickness of the shell insulating the core thus reducing heat loss. Heat flow by conduction varies inversely with the distance; therefore, changes in skin blood flow affects heat loss by convection and conduction (Wenger, 1996).

In a thermoneutral zone, environmental temperature between 25-30 °C, the body is able to maintain its temperatures solely by changing skin blood flow. Cold temperatures stimulate sympathetic nerves causing vasoconstriction. However, vasomotor responses differ and skin temperatures vary by location. When environmental temperatures are below the thermoneutral zone maximal, vasoconstriction cannot prevent heat loss requiring the body to increase heat production (Vander et al., 1994). With surface cooling, skin sensors dominate and initiate shivering before the brain temperature changes to preserve core temperature (Holtzclaw, 1986). Muscle activity is the main source for heat production. Muscles respond to a cold environment by gradually increasing skeletal muscle contraction and potentially leading to shivering. Shivering thermogenesis rapidly produces heat and is controlled by descending pathways under primary control of the hypothalamus. Shivering does produce heat but at a significant cost (Vander et al., 1994). Shivering, while an effective short-term means of raising the body temperature in response to cold, is fatiguing. It creates an elevation in workload as the body mobilizes to meet the demands of the shivering process resulting in increased cerebral spinal fluid pressure, consuming energy stores, requiring marked increases in oxygen consumption and circulatory support (Abbey, 1982). Increased oxygen demand, as a result of shivering, is potentially dangerous to patients in the aeromedical environment where the partial pressure of oxygen is decreased. In the cold, the body also attempts to decrease physiological heat loss with an absence of sweat. However, insensible water loss from respiratory evaporation continues (Vander et al., 1994). Furthermore, dehydration, independent of ambient temperature, can cause the hypothalamic center to reset at higher levels (Rutledge & Holtzclaw, 1988).

The regulatory system is influenced by numerous factors. Body temperature is subject to modulation by the circadian cycle able to alter body temperature as much as 1.5°C in a 24 hour period. As a result of the circadian cycle, body temperatures are lowest in early morning hours, 0300-0600 hours, and peak in the late afternoon, 1500-1700 hours (Shoemaker & Refinetti, 1996). Body temperature is also influenced by hormonal changes. Plasma cortisol levels may influence circadian fluctuations by 0.2°- 0.3°C. Other hormones affect monthly variation in females related to ovulatory cycle and thyroid dysfunction affects the metabolic rate in both genders. Furthermore, many factors can disrupt hormonal and circadian cycles and thereby thermoregulation to include: emotional strain, pain, trauma, changes in sleep and wake schedule (Holtzclaw, 1993). Finally, the subcutaneous fat layer contributes to shell insulation affecting heat loss by conduction (Wenger, 1996).

Behavioral responses initiated by a perception of a cold environment can also decrease heat loss as an individual decreases exposed surface area, adding clothing, and moving to a warmer areas. Behavioral thermoregulation is a sub-system of thermoregulatory control. It is governed by perception of thermal comfort directing one to seek shelter. Behavioral thermoregulation is not well understood. Perception of thermal sensation and comfort respond more quickly than physiological thermoregulatory responses. If body heat loss is greater than heat production, core body temperature will fall. In humans a 1 °C change in core temperature elicits approximately nine times as great a thermoregulatory response as the same degree change in mean skin temperature (Wenger, 1996). While acclimatization to cold is not well studied, it is believed that over long term

exposure to cold an increased metabolic rate, insulating ability of skin fat, and withstanding cold without shivering will occur (Vander et al., 1994). Thermal regulatory balance obtained by behavioral and physiologic processes of the body actively generate, conserve, dissipate or redistribute heat.

In summary, humans possess a complex thermoregulatory system maintaining body temperature for optimum performance of the body. This thermoregulatory system is dynamic and is influenced by internal and external factors. In the aeromedical environment, stresses of flight affect the body and thermoregulatory system. Nurses must observe physiological adjustment and behaviors to identify thermal stresses on the body and manipulate the thermal environment to optimize the body's responses. However, the inflight thermal environment varies within the cabin and patients' physiological responses and perception to the thermal environment in the litters have not been investigated. It is imperative to gain an understanding of the thermal environment for litter patients and human responses to that inflight environment aiding the nurse to manipulate the thermal environment to decrease inflight thermal stress.

Research Reviewed

A review of the literature revealed that there are no research studies conducted inflight on fixed wind aircraft regarding thermal environment, human temperature responses on human perceptions of the thermal environment. All inflight, fixed wing studies investigated hypoxemia and pulse oximetry readings (Henry, Krenis, & Cutting, 1973) (Cottrell, Lebovitz, Rennell, & Kohn, 1995). Interestingly, investigators indicated the aircraft's ambient temperature may have caused poor digital perfusion and interfered with

the oximeter's reading (Bendrick, Nicolas, Krause, & Castillo, 1995). Inflight thermal studies have not been reported in the literature. Literature from three related fields were reviewed: inflight aeromedical helicopter hypothermia reports, laboratory investigations of related flight stresses, and perceptions of thermal environments research.

Helicopter studies

Recent studies were completed on hypothermic patients transported by helicopter. A retrospective analysis reviewed outcomes of seventeen patients hypothermic either pre-hospital or in the emergency room following helicopter transport (Fox, Thomas, Clemmer, & Grossman, 1988). They determined physiologic scoring systems were not predictive of outcome. Further, hospital length of stay, while somewhat related to the severity of hypothermia, was more drastically influenced by complicating factors. Finally, vigorous field rewarming was not essential to a good outcome. Rewarming methods were identified while ambient temperature and flight duration were not obtained. It was noted as the severity of hypothermia increased, less pre-hospital rewarming was completed, and rewarming techniques in the hospital became more aggressive (Fox et al., 1988). The duration of helicopter transport may significantly affect outcomes for severely hypothermic patients.

A 1994 study investigated the association of neuromuscular blockade and incubation with hypothermia in the helicopter transport of 144 patients (Semonin-Holleran, Davis, & Storer, 1994). The authors concluded cooler ambient temperatures, the amount of time spent outside the hospital, and use of neuromuscular blocking agents increased the risk for patients to become hypothermic. Finally, a 1996 study monitored 78 patients transported

from one hospital to another via helicopter (Fiege, Rutherford, & Nelson, 1996). They found 66 of the 75 patients experienced temperature changes during transport, and yet only 6.7% of these were considered significant. Authors determined nonhypothermic patients transported relatively short distances by helicopter do not become hypothermic when covered by blankets and maintained at a cabin temperature around 23.6°C. This highlights the necessity to be knowledgeable of cabin ambient air temperatures. It is important to note patients transported directly from accident scenes were excluded from the study. Similar studies need to be completed for fixed wing flights which are of longer duration.

Laboratory studies

A limited number of human laboratory studies exploring relationships between the stresses experienced in the flight environment have been completed. All laboratory studies were tightly controlled and utilized sophisticated measuring and recording devices. The subjects of these studies, however, were limited only to males, and the sample sizes were small, ranging from six to twenty-two subjects. Robinson & Haymes (1990) investigated hypoxia and cold environment collecting data from subjects at rest and exercise. The authors suggest cold exposure increases peripheral resistance while hypoxia increases cardiac output and promotes vasodilatation. The combined effect on the body resulted in increased cardiac work and energy requirements. At rest, the calorigenic responses appeared impaired increasing the body's reliance on shivering for heat production. Furthermore, increased heat loss occurred during exercise in the hypoxic/cold environment from increased ventilation and cutaneous vasodilatation. Finally, ventilation and oxygen uptake increased in the cold environment, regardless of the presence of oxygen. Another

study investigating the relationship of reduced oxygen and thermogensis failed to demonstrate a significant difference between the normoxic and hypoxic cold subjects at rest (Reading, Roberts, Hodgdon, & Pozos, 1996).

A third study investigated responses of native Peruvian low and highlanders to a cold environment at two altitudes. Both groups were exposed to two temperature controlled rooms, 26°C and 10°C, at sea level and at a high altitude, 150 meters and 4,360 meters respectively. Both groups increased oxygen uptake in the high altitude/cold environment. However, highlander responses significantly smaller than lowlander's. Interestingly, lowlander reported that 26°C felt the same at both altitudes yet perceived feeling colder when exposed to 10°C at the higher altitude compared to 10°C at sea-level (Blatteis & Lutherer, 1976). One study investigated the effect of vibration on thermoregulatory responses. This study focused on vibration's effect on sweating in a warm environment. Their data demonstrated vibration reduces the efficiency of thermoregulation at rest by increasing vasoconstriction and decreasing sweating (Spaul, Spear, & Greenleaf, 1986).

Perception studies

The final area of literature reviewed focused on thermal comfort perception. Thermal comfort laboratory studies were first published in 1923. Since the 1920's thermal comfort studies have used nominal scales to collect temperature or comfort data, using four to nine descriptors. One early study used three subjects to rate comfort sensation and thermal sensation separately. In addition to sensory measurements, physical data were collected to include: metabolism, evaporation loss, skin and internal body temperatures.

Data supported the conclusions that the range of thermal comfort lies between 28°C-30°C. Furthermore, sense of discomfort increases more rapidly from falling ambient temperatures than rising temperatures and serious discomfort from cold does not appear during extended exposures until temperatures fall below 21°C (Gagge, Stolwijk, & Hardy, 1967). A later study attempted to quantify thermal discomfort. Data from twenty subjects confirmed that cold discomfort occurred more rapidly than warm discomfort with temperature shifts from neutral. Researchers emphasized that the stimulus level must be measured in relation to the 'absolute threshold' defined as comfort (Stevens, Marks, & Gagge, 1969). Today visual analogs are commonly used to attain thermal and comfort perceptions (Rutledge, 1989).

A current term for this 'absolute threshold' is set-point temperature. According to Cabanac (1972), the 24 hour-temperature cycle results from changes in the set-point temperature. When the core temperature is below the set-point a warm stimulus is pleasant and a cool stimulus feels unpleasant and visa versa when core temperature is above the set-point (Cabanac, Massonnet, & Belaiche, 1972). A 1987 study with five subjects demonstrated that variations in metabolic heat production and temperatures in response to diet-induced thermogenesis did not affect thermal sensory scores (Nielsen, 1987). Another 1987 study utilized the concept of set-point to investigate thermal comfort of obese women. Researchers controlled for thermal cyclic variations and avoided the luteal phase of the menstrual cycle for 52 subjects in three groups, obese, normal and lean women. Zahorska-Markiewicz points out that the study demonstrated a significant difference between normal and thin control group and obese subjects in the perception of pleasantness of local

peripheral thermal stimuli and in the set-point temperature deduced from these sensations. The results indicated that the set point for many obese women is below body temperature (Zahorska-Markiewicz & Staszkiewicz, 1987).

A 1996 study with 32 undergraduate college students attempted to determine the set-point temperature preference of ambient air. Data demonstrated that male participants preferred higher ambient temperatures when their body temperatures were low. Such preference was not noted in females. However, researchers did not control for menstrual variations of females and is possibly the reason they were unable to demonstrate similar results (Shoemaker & Refinetti, 1996).

In conclusion, there are eight identified stresses of flight. These flight stresses negatively impact an individual. Decreasing the stresses of flight allows the patient to expend energy to improve their health status. Manipulation of the thermal environment is one stress of flight that the nurse is able to directly influence. However, inflight studies regarding the thermal environment or perceived thermal comfort of the patient to aid the nurse in manipulating this stimulus are not available in the literature. Inflight and laboratory studies indicate that inflight stresses affecting the body are complex. Furthermore, studies regarding thermal comfort demonstrate a variety of variables may affect individuals. This indicates the need to answer the identified research questions.

III METHODS

Design

The study had a non-experimental, descriptive, correlational design. All data were collected by the researcher during routine aeromedical training flights onboard the Hercules C-130 aircraft from December 20, 1997 to March 8, 1998. The 1997-1998 winter was affected by an El Nino weather pattern and considered to be the warmest on record for the continental United States (U.S.) The researcher flew with four separate aeromedical evacuation squadrons: the 433rd from Kelly Air Force Base (AFB) in San Antonio, Texas; the 43rd from Pope AFB in Fayetteville, North Carolina; the 622nd from Maxwell AFB in Montgomery, Alabama; and the 908th from MacDill AFB in Tampa, Florida. Data were collected on ten aeromedical evacuation training flights originating from four locations: Kelly AFB in San Antonio, Texas, Eglin AFB in Fort Walton Beach, Florida, Pope AFB in Fayetteville, North Carolina and MacDill AFB in Tampa, Florida. The study did not control mission operations including: flight operations, departure times, aircraft or flight duration. Data could not be obtained on nine planned missions over the course of the study period: one mission was cancelled due to insufficient aeromedical crew; C-130 weather aircraft that do not allow configuration of centerline stations were utilized on four missions; two missions were cancelled as a result of aeromedical assets deployed to the Middle East responding to an Iraq crisis; one mission did not receive C-130 aircraft support, and one aircraft was not configured to meet the study's requirements.

Sample

The sample consisted of reserve and active duty aeromedical evacuation squadron personnel from: the 433rd at Kelly Air Force Base (AFB) in San Antonio, Texas; the 43rd at Pope AFB in Fayetteville, North Carolina; the 622nd at Maxwell AFB in Montgomery, Alabama; and the 908th at MacDill AFB in Tampa, Florida. All squadron personnel were eligible to participate in the study, without restrictions for age or gender. Personnel already scheduled for the missions as simulated patients or in a non crew position were eligible to volunteer to participate in the study. Subjects could not wear long underwear nor participate in the study on more than one flight. To ensure consistency in clothing, all subjects wore duty uniform, underwear and tee shirts. Long underwear, jackets and head covers were not worn. The number of available subjects varied greatly for each flight. Frequently crew staffing fluctuated the morning of the flight as flight personnel canceled. Typically, two to four subjects were available to participate on any given flight. The maximum number of subjects from which the researcher collected data on one flight was five. This convenience sample was anticipated to be a homogenous group of adults, in good health by virtue of being on flight status, and within an prescribed fitness condition as directed by military fitness and weigh standards. Flight personnel complete an annual physical examination to include urinalysis, cholesterol, HIV, vision, test in addition to a physical assessment and require specific waivers to take medications. Thus, the sample population could be considered to be healthier than the general population.

Procedure

Aeromedical evacuation squadrons were contacted and cooperation of senior

leadership was obtained. Coordination of the feasibility of flying on the training flights was completed in advance with squadron personnel.

The morning of the flight the researcher met the aeromedical crew at the squadron's facility. The purpose of the study, a description of the design, identification of potential risks and benefits were presented to the flight crew by the researcher. All flight personnel in non crew positions were asked to participate in the study at this time. Upon volunteering to participate subjects received a clipboard. The clipboard had an informed consent form (See Appendix C), a visual analog data sheet (See Appendix B), a demographic data sheet (See Appendix D) and taped to the board a picture of the placement locations for the skin temperature probes (See Appendix E). To match visual analog data and demographic data to flight data an identification number was assigned to each subject as they entered the study. The informed consent form was completed prior to departure from the squadron. Subjects were given verbal instructions regarding completion of the visual analog sheet, demographic data sheet, and placement of the skin and tympanic temperature probes. Skin temperature sensors were applied by subjects to the chest, bicep, thigh and calf with probe connection exposed from flight suit. Placement timing of the skin probes varied. Some subjects placed the skin probes at the squadron or command post prior to departure to the flightline. Others placed the probes just prior to take off on the flightline. All tympanic probes were placed by the subjects once they were positioned on the liter on the flightline or in the aircraft. Finally, subjects were randomly assigned to one of the eight litter positions. Assignments were dependent on the aircraft configuration for that specific flight. Placement

of subjects was monitored to ensure even distribution of the subjects into the litter positions over the course of the study.

At the aircraft, participants were placed on their assigned litter and a tympanic temperature probe positioned by the subject per manufacture's instruction. Ambient air temperature, air flow, tympanic temperature, and skin temperature measurements were obtained by the researcher and recorded on the Temperature Data Sheet (See Appendix F). Tympanic and skin temperature probes remained in place for the duration of the flight. The ProPaq® 106EL monitor moved to each subject to obtain the tympanic and skin temperature measurements. At the same time the ambient air temperature, air flow, tympanic temperature and skin temperature data were collected by the researcher, the participants completed the visual analog scales for thermal and comfort perceptions (See Appendix B). Ambient air temperature and air flow were also measured at litters in the identified study's positions yet, not occupied by a subject.

Inflight data collection began when the loadmaster indicates it was safe to move within the cabin, approximately twenty minutes following takeoff. Ambient air temperature, air flow, tympanic temperature, skin temperature measurements were obtained at fifteen minute intervals by the researcher inflight and recorded on the temperature data collection sheet as noted in preflight procedures. Participants completed the visual analog data collection sheet for thermal perception and thermal comfort at fifteen minute intervals inflight, at the same time the temperature readings were obtained. Subjects were encouraged to remain on their litter for the duration of the flight. However, removal from the litter position for short periods to use toilet facilities was permitted. Subjects were

allowed to eat and drink room temperature liquids. On each flight a watercooler without ice was available to provided water for participants. To ensure safety, the investigator did not collect data during aircraft takeoff, landing, or periods of significant turbulence. Data collection was also dependent on training/mission requirements. For example, preflight data could not be obtained on flights with engine running onloads nor post flight on missions with engine running offloads. Engine running loading is performed in hostile areas and allows for the immediate departure of the aircraft if security deteriorates during loading operations. Thus, loading and departure procedures occur quickly and did not allow sufficient time to collect data.

Post flight, final ambient air temperature, air flow, tympanic temperature, and skin temperature measurements were obtained and recorded by the researcher and participants completed the visual analog data collection sheet for thermal perception and thermal comfort. Subjects in Texas and Florida who completed the visual analog and demographic data sheets received one single dollar lottery ticket. Subjects who participated in North Carolina did not receive lottery tickets. Participants removed tympanic and skin sensors following post flight data collection. The researcher completed a Flight Information Data Sheet (See Appendix G) before disembarking the aircraft. The flight information data sheet included: flight number, aircraft model, aircraft tail number, year aircraft manufactured, cabin altitude, take off time, landing time, flight time and aircraft thermal equipment malfunctions.

Protection of Human Subjects

Human subjects were essential for this inflight study to obtain data recording tympanic temperature, skin temperature, thermal and comfort perceptions experienced in litter positions onboard a Hercules C-130. The study preserved the dignity of human subjects. Subjects were aeromedical flight personnel present on the aircraft regardless of study participation. There were not any identified risks for subjects as a result of participation in this study. There were not any direct benefits to individuals who elected to participate. All participants were volunteers. Subjects' confidentiality was maintained. Subjects were fully informed and signed the informed consent form prior admission to the study by the researcher. The signed consent forms were kept locked in the School of Nursing room number 2.134. Participants could withdraw from the study at any time without explanations or repercussions. Ethical considerations were strictly adhered to by the researcher. Approval from Institutional Review Boards of Wilford Hall Medical Center (WHMC) and The University of Texas Health Science Center at San Antonio were obtained.

Instruments

The study utilized a variety of instruments. All electronic equipment provided digital displays and completed electromagnetic interference testing (EMI) prior to initiation of the study. All instruments were operated by a single researcher. The Davis® Instruments hot wire thermo-anemometer model 407123 (Baltimore, Maryland) measured ambient air temperature and air flow. Temperature specifications are as follows: 0.1°C resolution, accuracy ±0.8°C and range 0 to 50°C. Air flow measures a range from 0.2 - 20.0 m/s,

resolution 0.1 m/s, accuracy ±3%. The devices were purchased for this study and delivered November 1997. Calibration was completed prior to delivery and manufacturer advises the device be calibrated annually (Davis, 1997).

Skin and tympanic temperature measurements were obtained by ProPaq® 106EL (Protocol Systems, Inc., Beaverton, OR), approved for inflight use and is currently utilized by Critical Care Aeromedical Transport teams. Internal instrument calibration is completed when the unit is turned on. Tympanic temperature sensor, TTSP-400 by Respiratory Support Products, Inc. (Smiths Industries Medical Systems Co., Irvine, CA) was used to obtain tympanic temperature. The range of the probe is 0-60°C, with a 0.1° resolution and accuracy ±0.2°C. The tympanic temperature sensor was placed by subjects per manufacturer instruction: insert sensor tip into canal by a) pulling pinna to superior/posterior direction, b) squeeze and roll foam cylinder between fingers, c) gently insert foam portion inside the ear with a twisting motion, d) stop when resistance is felt then pull slightly out, and allow three minutes of equilibration time prior to monitoring. Skin surface temperature probe (Medtronic Electromedics, Parker, CO) obtained skin temperatures. The range of the probe is 0-50°C, with a 0.1° resolution and accuracy ±0.2°C at 37°C.

Visual analog scales were used to measure the perception of a variety of stimuli (Johnson, 1997). The thermal and comfort perception visual analogs measure 10 centimeters each in length. To ensure accurate length of the scale the visual analog data sheet was computer generated and not copied. The thermal perception and thermal comfort

analog scales utilized for the study have been determined by experts in thermoregulation to be valid and reliable measurements (Rutledge, 1989). The thermal and comfort perception scores were obtained by measuring the location of mark on the analog scale to the nearest millimeter. In this study the ten centimeters line is anchored at one end with cold = 0 and at the other end hot = 10 while intense discomfort = 0 and extreme comfort = 10.

IV RESULTS

Subjects were placed on litters in one of eight litter positions G 1/4, H 1/4, A 1/4 and B 1/4 onboard C-130 aircraft (See Appendix A). Thirty-four subjects participated in the study. Data were collapsed into four areas within the cargo compartment: litter positions G 4 and H 4 were considered front/top, G 1 and H 1 were front/bottom, A 4 and B 4 were back/top, A 1 and B 2 were back/bottom. At the completion of the study, the distribution of the subjects into the litter positions was as follows: front/top N=7, front/bottom N=7, back/top N=11, back/bottom N=9. Although as many as fourteen inflight measurement were obtained for some subjects, the results were limited to preflight, postflight, and the first eight inflight measurements. Flight duration was not standardized. As a result, subjects did not have an identical number of readings and numbers within litter groupings significantly decreased after the eighth inflight reading.

Demographic Data

Thirty-four subjects, nineteen males and fifteen females, participated on ten flights. Specifically, gender distribution by litter location was as follows: front/top - 42.9% male (N=3) and 57.1% female (N=4), front/bottom - 42.9% male (N=3) and 57.1% female (N=4), back/top - 72.7% male (N=8) and 27.3% female (N=3), and back/bottom - 55.6% male (N=5) and 44.4% female (N=4). Gender distribution between the four litter groups by Person Chi-square was not significant, $p = 0.526$. Age ranged from 19 to 56 years with a group mean of 43.6 years. An ANOVA was used and found no significant difference in age between the four litter groups, $F = 0.211$ and $p = 0.888$. Height ranged from 56 to 73 inches with a group mean of 66.1 inches. Height difference between the four litter groups was not

significant, $F = 1.237$ and $p = 0.313$ by ANOVA. Weight ranged from 110 to 240 pounds with a group mean of 161.1 pounds. Weight difference between the four litter groups were not significant $F= 0.674$ and $p = 0.575$ by ANOVA. Body mass index ranged from 19 to 30 with a group mean of 25.5. Subject's body mass index was not greater than 30, considered an obese measurement (Service", 1994). Here body mass index $F = 0.695$ and $p= 0.563$ by ANOVA between the four litter groups. Thus, no significance between litter positions were established for demographic data.

Aircraft Data

Aircraft data were collected on the ten C-130 aeromedical training flights. Three aircraft models participated in the study: E, H2, and H3. The year of manufacture for the aircraft ranged from 1962 to 1993. The maximum cabin altitude ranged from sea level to 2,000 feet. Flight time ranged from two to four hours. Take off times varied widely but ranged from 8:00 a.m. to 1:50 p.m.

Flight Data

The ambient air temperature, air flow, thermal perception scale, comfort perception scale, tympanic temperature and skin temperature reading were obtained preflight, post flight and at 15 minute intervals inflight. The results are presented in relationship to study questions. Here data concerned with questions #1 and #2 are presented:

Question #1.) To what extent do ambient air temperature and air flow at four litter positions change over time during aeromedical evacuation in a C-130?

Question #2.) Are there differences in average ambient air temperature and air flow at each litter position in different locations within the cargo compartment of a C-130 during aeromedical evacuation?

Ambient Air Temperature

Ambient air temperature data results are reported in degrees Celsius (°C) and rounded to the nearest tenth of a degree. In this study, the front/top litter position ambient air temperature readings were as follows: preflight - range 12.6°C to 21°C, mean 15.5°C, and standard deviation of 2.8; inflight 1 - range 20.5°C to 25°C mean 23.2°C, and standard deviation of 1.7; inflight 2 - range 20.1°C to 25.9°C, mean 24.7°C, and standard deviation of 2.1; inflight 3 - range 22.1°C to 27.2°C, mean 24.7°C, and standard deviation of 1.8; inflight 4 - range 22.6°C to 28.5°C, mean 25.3°C and standard deviation of 2; inflight 5 - range 22.5°C to 27.6°C, mean 24.8°C and standard deviation of 1.7; inflight 6 - range 23.2°C to 28.5°C, mean 25.1°C, and standard deviation of 1.7; inflight 7 - range 23.8°C to 29.3°C, mean 25.8°C, and standard deviation of 2.2; inflight 8 - range 25.2°C to 28.2°C, mean 26.7°C, and standard deviation of 1.1; and post flight - range 24°C to 28.5°C, mean 25.6°C, and standard deviation of 1.5. Refer to Figure 1, Mean Ambient Air Temperature.

The front/bottom litter position ambient air temperature readings were: preflight - range 13.5°C to 18.7°C, mean 15.9°C, and standard deviation of 2.2; inflight 1 - range 19.9°C to 25.2°C, mean 21.6°C, and standard deviation of 1.9; inflight 2 - range 19.3°C to 25.9°C, mean 22.6°C, and standard deviation of 3; inflight 3 - range 19.7°C to 25.7°C, mean 23.3°C, and standard deviation of 2.2; inflight 4 - range 20.6°C to 26.6°C, mean 23.8°C and

standard deviation of 2.3; inflight 5 - range 20°C to 25.4°C, mean 23.1°C and standard deviation of 2.1; inflight 6 - range 20.7°C to 25.8°C, mean 23.7°C, and standard deviation of 1.8; inflight 7 - range 23.4°C to 27.1°C, mean 25.3°C, and standard deviation of 1.4; inflight 8 - range 22.6°C to 26.6°C, mean 25.3°C, and standard deviation of 1.6; and post flight - range 17.5°C to 26°C, mean 22.9°C, and standard deviation of 3.4. Refer to Figure 1, Mean Ambient Air Temperature.

The back/top litter position ambient air temperature readings were: preflight - range 10.9°C to 23.9°C, mean 16.7°C, and standard deviation of 3.7; inflight 1 - range 19°C to 25.6°C, mean 22.8°C, and standard deviation of 1.9; inflight 2 - range 20.6°C to 26.8°C, mean 23.9°C, and standard deviation of 1.9; inflight 3 - range 20.9°C to 27.3°C, mean 23.9°C, and standard deviation of 2.1; inflight 4 - range 21.1°C to 27.9°C, mean 23.6°C and standard deviation of 2.5; inflight 5 - range 21°C to 27.7°C, mean 24.1°C and standard deviation of 2.5; inflight 6 - range 20.3°C to 28.5°C, mean 24.3°C, and standard deviation of 2.7; inflight 7 - range 21.2°C to 27.3°C, mean 24.1°C, and standard deviation of 2.5; inflight 8 - range 20.3°C to 26.9°C, mean 23.9°C, and standard deviation of 2.4; and post flight - range 18.8°C to 27°C, mean 23.4°C, and standard deviation of 2.5. Refer to Figure 1, Mean Ambient Air Temperature.

The back/bottom litter position ambient air temperature readings were as follows: preflight - range 10.6°C to 23.9°C, mean 16.7°C, and standard deviation of 4.3; inflight 1 - range 18.9°C to 26°C, mean 23.2°C, and standard deviation of 2.5; inflight 2 - range 17.8°C to 26.3°C, mean 22.5°C, and standard deviation of 2.6; inflight 3 - range 16.4°C to 25.2°C,

mean 22.1°C, and standard deviation of 3; inflight 4 - range 15.1°C to 26.6°C, mean 22°C and standard deviation of 3.6; inflight 5 - range 16.8°C to 25.9°C, mean 22°C and standard deviation of 3.2; inflight 6 - range 18.5°C to 26.4°C, mean 22.4°C, and standard deviation of 2.6; inflight 7 - range 18.4°C to 25.8°C, mean 22.5°C, and standard deviation of 2.9; inflight 8 - range 19.3°C to 25.6°C, mean 22.6°C, and standard deviation of 2.8; and post flight - range 21.8°C to 27.2°C, mean 24.2°C, and standard deviation of 1.8. Refer to Figure 1, Mean Ambient Air Temperature.

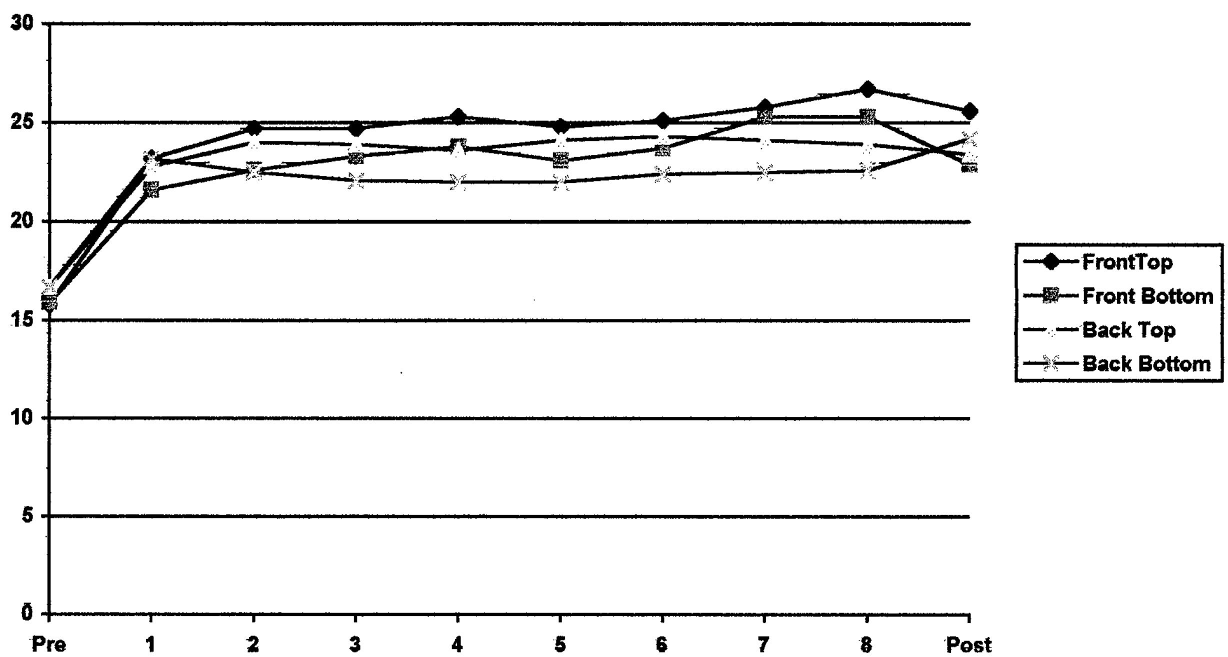


Fig. 1 Mean Ambient Air Temperature

An ANOVA was accomplished to determine significance of ambient air temperature between the four litter positions. A significance was noted at inflight reading 8, p=0.034. Refer to Table 1, Ambient Air Temperature Between Litter Positions ANOVA for specific results.

	F	p
Pre flight	0.184	0.907
Inflight 1	1.034	0.390
Inflight 2	1.697	0.186
Inflight 3	2.081	0.120
Inflight 4	2.165	0.110
Inflight 5	2.363	0.088
Inflight 6	2.155	0.112
Inflight 7	2.140	0.127
Inflight 8	3.515	0.034
Postflight	1.640	0.200

Table 1 Ambient Air Temperature Between Litter Positions ANOVA

A Duncan post hoc test was completed for inflight 8 reading that the ANOVA determined was significant, $p = 0.034$. The Duncan indicated that the front/top litter position was significantly warmer at 26.7°C than the cooler back/bottom litter position at 22.6°C. The front/bottom and back/top were not significantly different from the other litter positions at any reading obtained.

A repeated measures ANOVA for ambient air temperature was completed for inflight readings 2-6. It compared the means of the litter locations over time and did not demonstrate significance, $p= 0.791$. The trend of the readings between the liter positions over the coarse of the flight did not significantly differ However, the repeated measure means of each litter locations approached significance $p= 0.054$, demonstrating the front/top was warmer at 24.9°C than the back/bottom at 21.9°C.

During the second flight of data collection the researcher noted that the ambient air temperature in a given litter position appeared to fluctuate. The researcher attempted to

collect some data on this observation by obtaining ambient air temperature reading from the head, middle, and foot of the litter once for each subject during a flight. The timing of this additional data varied and presented in the following: Table 2, Random Ambient Air Temperature Readings Front/Top Litters, Table 3, Random Ambient Air Temperature Reading Front/Bottom Litters, Table 4, Random Ambient Air Temperature Readings Back/Top Litters, and Table 5, Random Ambient Air Temperature Readings Back/Bottom Litters.

Head	Middle	Foot
24.6°C	23.2°C	25.8°C
26.2°C	25.9°C	26.4°C
25.0°C	24.1°C	25.8°C
26.4°C	26.0°C	26.4°C
24.2°C	24.2°C	24.6°C

Table 2 Random Ambient Air Temperature Readings Front/Top Litters

Head	Middle	Foot
25.1°C	25.8°C	25.0°C
24.7°C	24.9°C	24.6°C
25.9°C	25.8°C	26.1°C
24.2°C	23.9°C	24.2°C
26.1°C	26.6°C	27.9°C
27.0°C	26.0°C	27.2°C
22.8°C	22.6°C	23.3°C

Table 3 Random Ambient Air Temperature Readings Front/Bottom Litters

Head	Middle	Foot
25.8°C	26.2°C	25.8°C
24.8°C	25.9°C	25.5°C
23.2°C	23.5°C	24.0°C
21.7°C	21.8°C	22.5°C
25.4°C	26.9°C	25.4°C
26.5°C	26.6°C	26.4°C
22.3°C	21.4°C	22.4°C
23.6°C	21.1°C	22.0°C
22.0°C	21.1°C	22.6°C

Table 4 Random Ambient Air Temperature Readings Back/Top Litters

Head	Middle	Foot
23.1°C	26.6°C	24.6°C
20.3°C	22.2°C	21.7°C
21.3°C	26.2°C	20.8°C
21.6°C	22.2°C	22.1°C
25.5°C	25.2°C	25.8°C
15.5°C	18.6°C	17.2°C
14.6°C	15.1°C	13.6°C
22.0°C	22.9°C	22.6°C

Table 5 Random Ambient Air Temperature Readings Back/Bottom Litters

Air Flow

Air flow results are presented in meters per second (m/s) and is reported to the nearest hundredth. Air flow for the front/top litter position readings were as follows: preflight - range 0 to 0.2 m/s, mean 0.09 m/s, and standard deviation 0.09; inflight 1 - range 0 to 0.4 m/s, mean 0.11 m/s, and standard deviation 0.17; inflight 2 - range 0 to 0.2 m/s,

mean 0.09 m/s, and standard deviation 0.09; inflight 3 - range 0 to 0.5 m/s, mean 0.14 m/s, and standard deviation 0.2; inflight 4 - range 0 to 0.3 m/s, mean 0.13 m/s, and standard deviation of 0.11; inflight 5 - range 0 to 0.2 m/s, mean 0.04 m/s, and standard deviation 0.08; inflight 6 - range 0 to 0.2 m/s, mean 0.03 m/s, and standard deviation 0.08; inflight 7 - range 0 to 0.3 m/s, mean 0.08 m/s, and standard deviation 0.13; inflight 8 - range 0 to 0.2 m/s, mean 0.04 m/s, and standard deviation 0.09; and post flight - range 0 to 0.1 m/s, mean 0.02 m/s, and standard deviation 0.04. Refer to Figure 2, Mean Air Flow.

Air flow for the front/bottom litter position readings were: preflight - range 0 to 0.2 m/s, mean 0.1 m/s, and standard deviation 0.09; inflight 1 - range 0 to 0.4 m/s, mean 0.11 m/s, and standard deviation 0.16; inflight 2 - range 0 to 0.3 m/s, mean 0.1 m/s, and standard deviation 0.12; inflight 3 - range 0 to 0.5 m/s, mean 0.13 m/s, and standard deviation 0.18; inflight 4 - range 0 to 0.4 m/s, mean 0.14 m/s, and standard deviation of 0.16; inflight 5 - range 0 to 0.2 m/s, mean 0.09 m/s, and standard deviation 0.09; inflight 6 - range 0 to 0.3 m/s, mean 0.13 m/s, and standard deviation 0.13; inflight 7 - range 0 to 0.3 m/s, mean 0.12 m/s, and standard deviation 0.16; inflight 8 - range 0 to 0.3 m/s, mean 0.12 m/s, and standard deviation 0.16; and post flight - range 0 to 0.7 m/s, mean 0.33 m/s, and standard deviation 0.31. Refer to Figure 2, Mean Air Flow.

Air flow for the back top litter position readings were: preflight - range 0 to 0.4 m/s, mean 0.17 m/s, and standard deviation 0.12; inflight 1 - range 0 to 0.5 m/s, mean 0.15 m/s, and standard deviation 0.17; inflight 2 - range 0 to 0.4 m/s, mean 0.08 m/s, and standard deviation 0.14; inflight 3 - range 0 to 0.3 m/s, mean 0.13 m/s, and standard deviation 0.14; inflight 4 - range 0 to 0.3 m/s, mean 0.09 m/s, and standard deviation of 0.12; inflight 5 -

range 0 to 0.5 m/s, mean 0.18 m/s, and standard deviation 0.18; inflight 6 - range 0 to 0.5 m/s, mean 0.17 m/s, and standard deviation 0.16; inflight 7 - range 0 to 0.4 m/s, mean 0.21 m/s, and standard deviation 0.15; inflight 8 - range 0 to 0.6 m/s, mean 0.19 m/s, and standard deviation 0.22; and post flight - range 0 to 0.6 m/s, mean 0.16 m/s, and standard deviation 0.2. Refer to Figure 2, Mean Air Flow.

Air flow for the back/bottom litter position readings were as follows: preflight - range 0 to 0.9 m/s, mean 0.22 m/s, and standard deviation 0.31; inflight 1 - range 0 to 0.3 m/s, mean 0.14 m/s, and standard deviation 0.12; inflight 2 - range 0.1 to 0.3 m/s, mean 0.18 m/s, and standard deviation 0.07; inflight 3 - range 0 to 0.5 m/s, mean 0.22 m/s, and standard deviation 0.17; inflight 4 - range 0 to 0.5 m/s, mean 0.2 m/s, and standard deviation of 0.18; inflight 5 - range 0.1 to 0.5 m/s, mean 0.29 m/s, and standard deviation 0.12; inflight 6 - range 0 to 0.4 m/s, mean 0.21 m/s, and standard deviation 0.12; inflight 7 - range 0 to 0.3 m/s, mean 0.13 m/s, and standard deviation 0.1; inflight 8 - range 0 to 0.5 m/s, mean 0.23 m/s, and standard deviation 0.21; and post flight - range 0 to 0.7 m/s, mean 0.11 m/s, and standard deviation 0.24. Refer to Figure 2, Mean Air Flow.

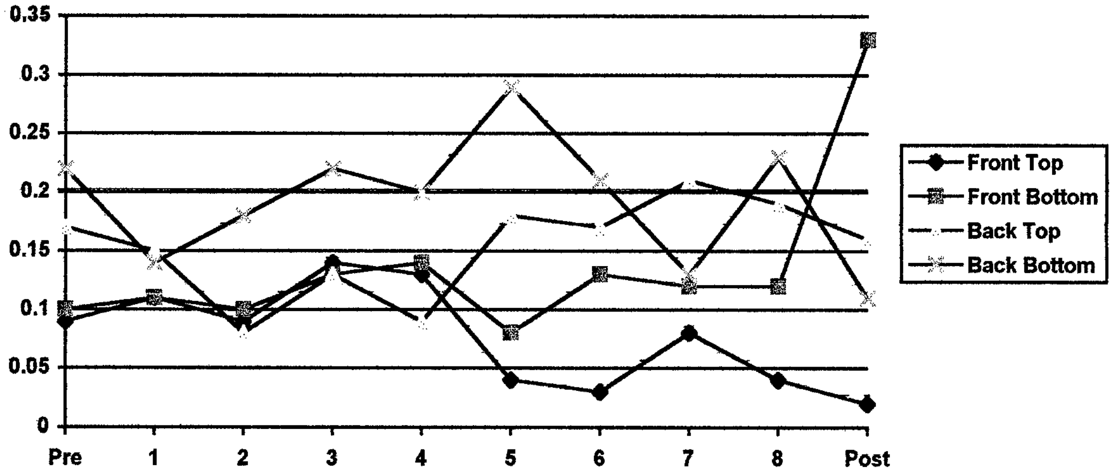


Fig. 2 Mean Air Flow

An ANOVA was completed comparing air flow at each time period between the four litter positions in Table 6, Air Flow Between Litter Positions ANOVA. Significance is noted at inflight 5 reading p= 0.002. A Duncan post hoc test demonstrated the back/bottom litter air flow at 0.081m/s, was significantly different from the front/top litter air flow at 0.04m/s.

	F	p
Pre flight	0.848	0.477
Inflight 1	0.155	0.926
Inflight 2	2.356	0.089
Inflight 3	0.686	0.567
Inflight 4	1.161	0.338
Inflight 5	6.236	0.002
Inflight 6	2.853	0.052
Inflight 7	1.084	0.378
Inflight 8	1.148	0.354
Postflight	2.291	0.098

Table 6 Air Flow Between Litter Positions ANOVA

The following results are related to study question #3:

Question #3.) To what extent do core temperature, skin temperature, thermal perception and thermal comfort of individuals in litter positions change over time during aeromedical evacuation in a C-130?

Thermal perception

Thermal perception was measured using a visual scale with 0 as cold and 10 as hot. Thus, the lower the thermal perception score the colder the subject perceived the ambient air temperature to be. The results were rounded to the nearest tenths. The thermal perception results for the front/top litter positions were as follows: preflight - range 0.2 to 6.1, mean 3.6, and standard deviation of 1.9; inflight 1 - range 3.5 to 5.9, mean 4.8, and standard deviation of 0.8; inflight 2 - range 4 to 6.8, mean 5.5, and standard deviation of 0.9; inflight 3 - range 4.1 to 7.4, mean 5.7, and standard deviation of 1.1; inflight 4 - range 3.9 to 7.1, mean 5.3, and standard deviation of 0.9; inflight 5 - range 4 to 7.7, mean 5.7, and standard deviation of 1.3; inflight 6 - range 4.2 to 7.3, mean 5.5, and standard deviation of

1.2; inflight 7 - range 4.8 to 8, mean 6.4, and standard deviation of 1.3; inflight 8 - range 4.6 to 6.6, mean 5.4, and standard deviation of 0.9; and post flight - range 3.1 to 5.8, mean 4.9, and standard deviation of 1.1. Refer to Figure 3, Mean Score for Thermal Perception.

The thermal perception results for the front/bottom litter position were as follows: preflight - range 2.3 to 4.2, mean 3.4, and standard deviation of 0.6; inflight 1 - range 2.8 to 6.7, mean 4.3, and standard deviation of 1.4; inflight 2 - range 3.1 to 6.3, mean 4.4, and standard deviation of 1.1; inflight 3 - range 2.7 to 5.2, mean 4.3, and standard deviation of 0.9; inflight 4 - range 2.6 to 4.8, mean 3.7, and standard deviation of 0.9; inflight 5 - range 2.7 to 4.9, mean 3.8, and standard deviation of 0.9; inflight 6 - range 2.4 to 5.2, mean 3.9, and standard deviation of 1; inflight 7 - range 3.3 to 5.4, mean 4, and standard deviation of 0.9; inflight 8 - range 3.9 to 5.7, mean 4.7, and standard deviation of 0.7; and post flight - range 0.8 to 5.3, mean 3.5, and standard deviation of 1.5. Refer to Figure 3, Mean Score for Thermal Perception.

The thermal perception results for the back/top litter positions were as follows: preflight - range 2.8 to 6.7, mean 4.4, and standard deviation of 1.1; inflight 1 - range 1.6 to 9.3, mean 4.7, and standard deviation of 2.1; inflight 2 - range 3.2 to 6.2, mean 4.6, and standard deviation of 1; inflight 3 - range 3 to 6.5, mean 4.85, and standard deviation of 1.1; inflight 4 - range 2.5 to 6.9, mean 4.3, and standard deviation of 1.3; inflight 5 - range 2.4 to 5.6, mean 3.8, and standard deviation of 1; inflight 6 - range 2.4 to 6.4, mean 4.1, and standard deviation of 1.4; inflight 7 - range 2.1 to 6.2, mean 3.8, and standard deviation of 1.4; inflight 8 - range 1.8 to 6.2, mean 3.8, and standard deviation of 1.8; and post flight -

range 4.3 to 8.5, mean 6.5, and standard deviation of 1.5. Refer to Figure 3, Mean Score for Thermal Perception.

The thermal perception results for the back/bottom litter positions were: preflight - range 2.3 to 5.4, mean 3.3, and standard deviation of 1.1; inflight 1 - range 1.8 to 5.3, mean 3.5, and standard deviation of 1.2; inflight 2 - range 1.5 to 4, mean 2.9, and standard deviation of 0.9; inflight 3 - range 1.2 to 4.1, mean 2.7, and standard deviation of 1; inflight 4 - range 1.7 to 4.8, mean 3.3, and standard deviation of 1.1; inflight 5 - range 1.4 to 7.3, mean 3.2, and standard deviation of 2; inflight 6 - range 1.5 to 3.4, mean 2.7, and standard deviation of 0.7; inflight 7 - range 1 to 3.8, mean 2.6, and standard deviation of 1; inflight 8 - range 1 to 4.7, mean 2.5, and standard deviation of 1.6; and post flight - range 3.5 to 6.1, mean 4.5, and standard deviation of 1. Refer to Figure 3, Mean Score for Thermal Perception.

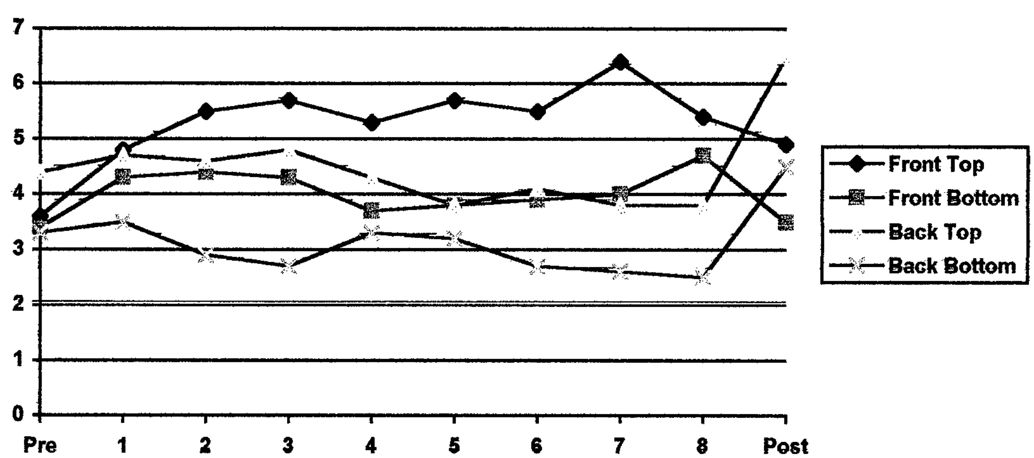


Fig. 3 Mean Score for Thermal Perception

An ANOVA was completed comparing thermal perception between the four litter positions and illustrates significance was obtained starting at inflight 2 reading, p= 0, and continued through postflight where p= 0.001. Refer to Table 7, Thermal Perception Between Litter Positions ANOVA for all data results.

	F	p
Pre flight	1.673	0.195
Inflight 1	1.318	0.287
Inflight 2	10.624	0
Inflight 3	12.166	0
Inflight 4	4.719	0.008
Inflight 5	4.825	0.008
Inflight 6	7.537	0.001
Inflight 7	9.111	0.001
Inflight 8	3.867	0.030
Postflight	7.363	0.001

Table 7 Thermal Perception Between Litter Positions ANOVA

Duncan post hoc testing was completed for inflight times 2 through 8 and postflight, see Table 8, Thermal Perception Duncan. This demonstrated the back/bottom litter position had a significantly lower thermal perception scores compared to the front/top litter position with higher thermal scores.

	Front/Top	Back/Bottom
Inflight 2	5.5	2.9
Inflight 3	5.7	2.7
Inflight 4	5.3	3.3
Inflight 5	5.7	3.2
Inflight 6	5.5	2.7
Inflight 7	6.4	2.6
Inflight 8	5.4	2.5
Postflight	6.5	3.5

Table 8 Thermal Perception Duncan

Comfort Perception

Comfort perception was measured using a visual scale with 0 as intense discomfort and 10 as extreme comfort. The results were rounded to the nearest tenths. The comfort perception results for the front/top litter positions were: preflight - range 0.3 to 7.1, mean 4.7, and standard deviation of 2.2; inflight 1 - range 3.7 to 6.2, mean 5.1, and standard deviation of 0.9; inflight 2 - range 3.7 to 7.9, mean 5.4, and standard deviation of 1.5; inflight 3 - range 3.7 to 7.8, mean 5.8, and standard deviation of 1.6; inflight 4 - range 5.1 to 9.4, mean 6.9, and standard deviation of 1.6; inflight 5 - range 4.8 to 9.4, mean 6.6, and standard deviation of 1.5; inflight 6 - range 4.4 to 10, mean 6.4, and standard deviation of 2.2; inflight 7 - range 5.2 to 7.8, mean 6.6, and standard deviation of 1.1; inflight 8 - range 5.3 to 7.3, mean 6.3, and standard deviation of 1; and post flight - range 4.4 to 10, mean 6.6, and standard deviation of 2.2. Refer to Figure 4, Mean Score for Comfort Perception.

The comfort perception results for the front/bottom litter positions were: preflight - range 2.6 to 9.7, mean 6.1, and standard deviation of 2.5; inflight 1 - range 2.3 to 9.4, mean 5.9, and standard deviation of 2.6; inflight 2 - range 2.8 to 8.5, mean 5.8, and standard

deviation of 2.3; inflight 3 - range 2.9 to 9.2, mean 5.9, and standard deviation of 2.3; inflight 4 - range 3.2 to 9.8, mean 5.3, and standard deviation of 2.2; inflight 5 - range 3.3 to 9.2, mean 5, and standard deviation of 2; inflight 6 - range 3.6 to 9.8, mean 5.6, and standard deviation of 2.2; inflight 7 - range 3.6 to 9.9, mean 5.5, and standard deviation of 2.6; inflight 8 - range 3.8 to 8.9, mean 5.6, and standard deviation of 2; and post flight - range 3 to 9, mean 5.3, and standard deviation of 2.2. Refer to Figure 4, Mean Score for Comfort Perception.

The comfort perception results for the back/top litter positions were: preflight - range 1.8 to 9.4, mean 5.7, and standard deviation of 2.4; inflight 1 - range 1.2 to 8.9, mean 4.9, and standard deviation of 2.5; inflight 2 - range 1.2 to 8.1, mean 4.6, and standard deviation of 2.1; inflight 3 - range 1.7 to 8, mean 5.5, and standard deviation of 1.8; inflight 4 - range 3.8 to 8, mean 5.1, and standard deviation of 1.2; inflight 5 - range 3.1 to 8.1, mean 4.9, and standard deviation of 1.6; inflight 6 - range 2.8 to 8.8, mean 5.1, and standard deviation of 1.7; inflight 7 - range 2.2 to 6.8, mean 4, and standard deviation of 1.8; inflight 8 - range 1.2 to 6.8, mean 4.2, and standard deviation of 2.2; and post flight - range 4.9 to 8.1, mean 6.8, and standard deviation of 1.1. Refer to Figure 4, Mean Score for Comfort Perception.

The comfort perception results for the back/bottom litter positions were: preflight - range 1.6 to 9.6, mean 4.7, and standard deviation of 2.8; inflight 1 - range 0.9 to 8, mean 4.2, and standard deviation of 2.3; inflight 2 - range 1.8 to 7.5, mean 3.5, and standard deviation of 1.9; inflight 3 - range 1.4 to 7.7, mean 3.3, and standard deviation of 1.8; inflight 4 - range 1.3 to 8.1, mean 3.7, and standard deviation of 2; inflight 5 - range 1.2 to

7.2, mean 2.9, and standard deviation of 2.2; inflight 6 - range 1.1 to 8.3, mean 3, and standard deviation of 2.4; inflight 7 - range 0.8 to 4.2, mean 2.1, and standard deviation of 1.3; inflight 8 - range 1.1 to 4.7, mean 2.2, and standard deviation of 1.5; and post flight - range 3.2 to 5.5, mean 4.6, and standard deviation of 1. Refer to Figure 4, Mean Score for Comfort Perception.

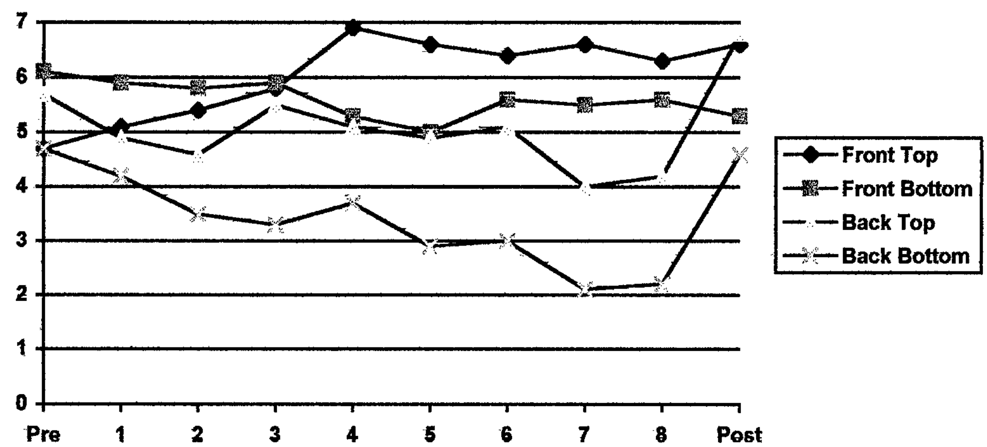


Fig. 4 Mean Score for Comfort Perception

An ANOVA was completed regarding comfort perception scores between the four litter positions, refer to Table 9, Comfort Perception Between Litter Positions ANOVA. At the third inflight reading significance of comfort perception between the litter positions was obtained, p= 0.022, and continued through inflight 8 reading with p= 0.016.

	F	p
Pre flight	0.642	0.594
Inflight 1	0.763	0.524
Inflight 2	2.188	0.110
Inflight 3	3.698	0.022
Inflight 4	4.505	0.010
Inflight 5	4.691	0.009
Inflight 6	3.522	0.028
Inflight 7	6.006	0.006
Inflight 8	4.652	0.016
Postflight	2.463	0.088

Table 9 Comfort Perception Between Litter Positions ANOVA

Duncan post hoc testing was completed on inflight readings 3 through 8 and results can be reviewed in Table 10, Comfort Perception Duncan. Significant difference in comfort perception was noted between front/top litter position with higher score than the back/bottom litter positions with lower scores.

	Front/Top	Back/Bottom
Inflight 3	5.9	3.3
Inflight 4	6.9	3.7
Inflight 5	6.6	2.9
Inflight 6	6.4	3.0
Inflight 7	6.6	2.1
Inflight 8	6.3	2.2

Table 10 Comfort Perception Duncan

Tympanic Temperature

The tympanic temperature readings are reported in degrees Celsius (°C) and are rounded to the nearest tenth. Tympanic temperatures for the front/top litter position were: preflight - range 22.6 to 33.1°C, mean 29.6°C, and standard deviation 4.3; inflight 1 - range 33.6 to 35.9°C, mean 35°C, and standard deviation 0.8; inflight 2 - range 28.6 to 35.9°C, mean 34.3°C, and standard deviation 2.6; inflight 3 - range 35.40 to 35.8°C, mean 35.6°C, and standard deviation 0.2; inflight 4 - range 35.2 to 37°C, mean 35.8°C and standard deviation of 0.6; inflight 5 - range 34.7 to 36.2°C, mean 35.3°C and standard deviation 0.5; inflight 6 - range 35.1 to 36.2°C, mean 35.6°C, and standard deviation 0.4; inflight 7 - range 35.2 to 35.6°C, mean 35.4°C, and standard deviation 0.2; inflight 8 - range 34.6 to 36.1°C, mean 35.5°C, and standard deviation 0.8; and post flight - range 34.6 to 35.6°C, mean 35.2°C, and standard deviation 0.4. Refer to Figure 5, Mean Tympanic Temperature.

Tympanic temperatures for the front/bottom litter position were: preflight - range 31.2 to 35.1°C, mean 33.5°C, and standard deviation 1.5; inflight 1 - range 33.1 to 36.1°C, mean 35.2°C, and standard deviation 1.1; inflight 2 - range 33.7 to 36.3°C, mean 35.3°C, and standard deviation 0.9; inflight 3 - range 34 to 36.1°C, mean 35.4°C, and standard deviation 0.7; inflight 4 - range 33.9 to 35.9°C, mean 35.3°C, and standard deviation of 0.7; inflight 5 - range 33.8 to 36.2°C, mean 35.3°C, and standard deviation 0.9; inflight 6 - range 34.3 to 36.3°C, mean 35.4°C, and standard deviation 0.7; inflight 7 - range 34.3 to 36.2°C, mean 35.3°C, and standard deviation 0.8; inflight 8 - range 33.5 to 35.9°C, mean 35.3°C,

and standard deviation 1; and post flight - range 33.2 to 35.9°C, mean 34.9°C, and standard deviation 0.9. Refer to Figure 5, Mean Tympanic Temperature.

Tympanic temperatures for the back/top litter position were: preflight - range 27.9 to 35.2°C, mean 32.6°C, and standard deviation 2.7; inflight 1 - range 32.2 to 36.3°C, mean 34.8°C, and standard deviation 1.3; inflight 2 - range 33.6 to 36.3°C, mean 35.3°C, and standard deviation 0.9; inflight 3 - range 33.2 to 36°C, mean 35.1°C, and standard deviation 0.8; inflight 4 - range 32.2 to 36.1°C, mean 35.2°C, and standard deviation of 1.1; inflight 5 - range 33.2 to 35.9°C, mean 34.9°C, and standard deviation 0.9; inflight 6 - range 32.8 to 36.3°C, mean 35.2°C, and standard deviation 1; inflight 7 - range 28.3 to 36.2°C, mean 34°C, and standard deviation 2.9; inflight 8 - range 33.8 to 36.2°C, mean 34.9°C, and standard deviation 0.9; and post flight - range 33.9 to 36.2°C, mean 35°C, and standard deviation 0.7. Refer to Figure 5, Mean Tympanic Temperature.

Tympanic temperatures for the back/bottom litter position were: preflight - range 26.7 to 33.8°C, mean 31.4°C, and standard deviation 2.6; inflight 1 - range 33.3 to 35.9°C, mean 34.5°C, and standard deviation 0.9; inflight 2 - range 33.3 to 35.9°C, mean 34.6°C, and standard deviation 0.9; inflight 3 - range 32.4 to 36.1°C, mean 34.5°C, and standard deviation 1.2; inflight 4 - range 31.7 to 35.9°C, mean 34.7°C, and standard deviation of 1.3; inflight 5 - range 30.8 to 36.3°C, mean 34.2°C, and standard deviation 1.7; inflight 6 - range 31.4 to 36.2°C, mean 34.7°C, and standard deviation 1.5; inflight 7 - range 34.2 to 35.8°C, mean 34.9°C, and standard deviation 0.8; inflight 8 - range 34.6 to 35.9°C, mean 35.2°C,

and standard deviation 0.6; and post flight - range 33.3 to 36°C, mean 34.7°C, and standard deviation 0.9. Refer to Figure 5, Mean Tympanic Temperature.

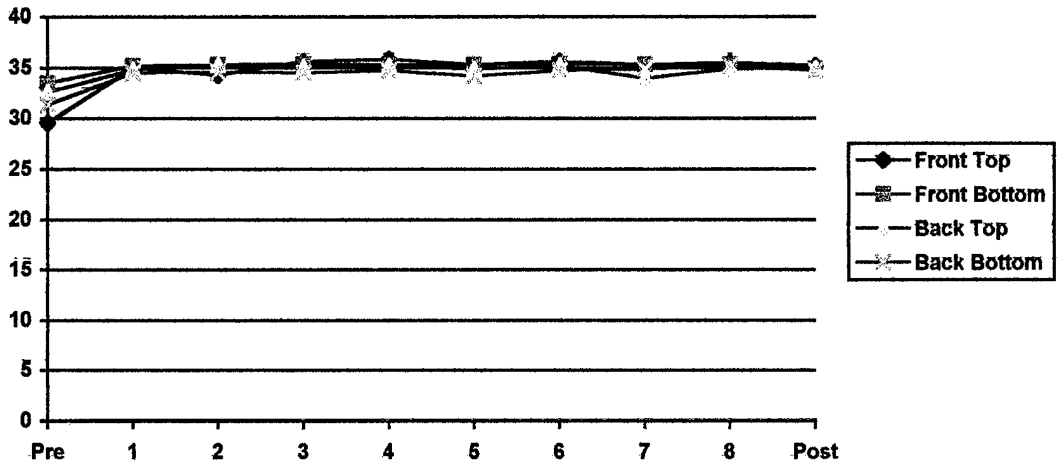


Fig. 5 Mean Tympanic Temperature

An ANOVA of tympanic temperatures comparing the four litter positions revealed no significant differences between litter positions, refer to Table 11, Tympanic Temperature Between Litter Positions ANOVA.

	F	p
Pre flight	1.858	0.165
Inflight 1	0507	0.681
Inflight 2	1.018	0.398
Inflight 3	2.724	0.062
Inflight 4	1.622	0.205
Inflight 5	1.858	0.159
Inflight 6	1.135	0.351
Inflight 7	0.773	0.525
Inflight 8	0.357	0.785
Postflight	0.511	0.679

Table 11 Tympanic Temperature Between Litter Positions ANOVA

Skin Temperature

Skin temperature data is reported in degrees Celsius (°C) and rounded to the nearest tenth. Skin temperatures for the front/top litter position were: preflight - range 29.3 to 32.2°C, mean 31.1°C, and standard deviation 1.1; inflight 1 - range 31.4 to 33.8°C, mean 32.8°C, and standard deviation 0.9; inflight 2 - range 31.9 to 33.9°C, mean 33.2°C, and standard deviation 0.7; inflight 3 - range 32.3 to 34°C, mean 33.4°C, and standard deviation 0.6; inflight 4 - range 32.5 to 34.4°C, mean 33.6°C, and standard deviation of 0.7; inflight 5 - range 32.8 to 34.4°C, mean 33.6°C, and standard deviation 0.7; inflight 6 - range 32.9 to 34.4°C, mean 33.8°C, and standard deviation 0.6; inflight 7 - range 33.8 to 34.5°C, mean 34.2°C, and standard deviation 0.3; inflight 8 - range 34.3 to 34.8°C, mean 34.5°C, and standard deviation 0.3; and post flight - range 34.1 to 35.2°C, mean 34.5°C, and standard deviation 0.6. Refer to Figure 6, Mean Skin Temperature.

Skin temperatures for the front/bottom litter position were: preflight - range 30.9 to 32.4°C, mean 31.6°C, and standard deviation 0.6; inflight 1 - range 31.1 to 33.6°C, mean 32.6°C, and standard deviation 0.8; inflight 2 - range 31.8 to 34°C, mean 32.8°C, and standard deviation 0.8; inflight 3 - range 32.1 to 33.7°C, mean 32.9°C, and standard deviation 0.5; inflight 4 - range 32 to 33.5°C, mean 32.9°C, and standard deviation of 0.5; inflight 5 - range 32.3 to 33.4°C, mean 32.9°C, and standard deviation 0.4; inflight 6 - range 32.1 to 33.6°C, mean 33°C, and standard deviation 0.6; inflight 7 - range 32.2 to 33.8°C, mean 33.1°C, and standard deviation 0.7; inflight 8 - range 32.3 to 34°C, mean 33.4°C, and standard deviation 0.7; and post flight - range 31.9 to 35.1°C, mean 33.6°C, and standard deviation 1. Refer to Figure 6, Mean Skin Temperature.

Skin temperatures for the back/top litter position were: preflight - range 29.2 to 33.4°C, mean 31.8°C, and standard deviation 1.7; inflight 1 - range 29.7 to 34.2°C, mean 32.7°C, and standard deviation 1.3; inflight 2 - range 29.5 to 34.1°C, mean 32.8°C, and standard deviation 1.3; inflight 3 - range 31.2 to 34°C, mean 33°C, and standard deviation 0.9; inflight 4 - range 29.4 to 34.3°C, mean 32.8°C, and standard deviation of 1.3; inflight 5 - range 31.3 to 34.6°C, mean 33°C, and standard deviation 1; inflight 6 - range 31.7 to 34.5°C, mean 33.1°C, and standard deviation 0.9; inflight 7 - range 32.5 to 34.4°C, mean 33.4°C, and standard deviation 0.8; inflight 8 - range 32.2 to 34.2°C, mean 33.2°C, and standard deviation 0.8; and post flight - range 31.5 to 35.1°C, mean 33.4°C, and standard deviation 0.9. Refer to Figure 6, Mean Skin Temperature.

Skin temperatures for the back/bottom litter position were: preflight - range 29.2 to 33.9°C, mean 31.6°C, and standard deviation 1.7; inflight 1 - range 31 to 34.3°C, mean 32.2°C, and standard deviation 1; inflight 2 - range 30.8 to 34.2°C, mean 31.9°C, and standard deviation 1.1; inflight 3 - range 29.9 to 33.8°C, mean 31.7°C, and standard deviation 1.2; inflight 4 - range 30.4 to 34.5°C, mean 31.8°C, and standard deviation of 1.4; inflight 5 - range 29.8 to 33.1°C, mean 31.4°C, and standard deviation 1; inflight 6 - range 28.7 to 34.2°C, mean 31.4°C, and standard deviation 1.8; inflight 7 - range 30.5 to 33.7°C, mean 31.5°C, and standard deviation 1.3; inflight 8 - range 30.4 to 34.1°C, mean 31.8°C, and standard deviation 1.4; and post flight - range 30.2 to 33.7°C, mean 31.6°C, and standard deviation 1.1. Refer to Figure 6, Mean Skin Temperature.

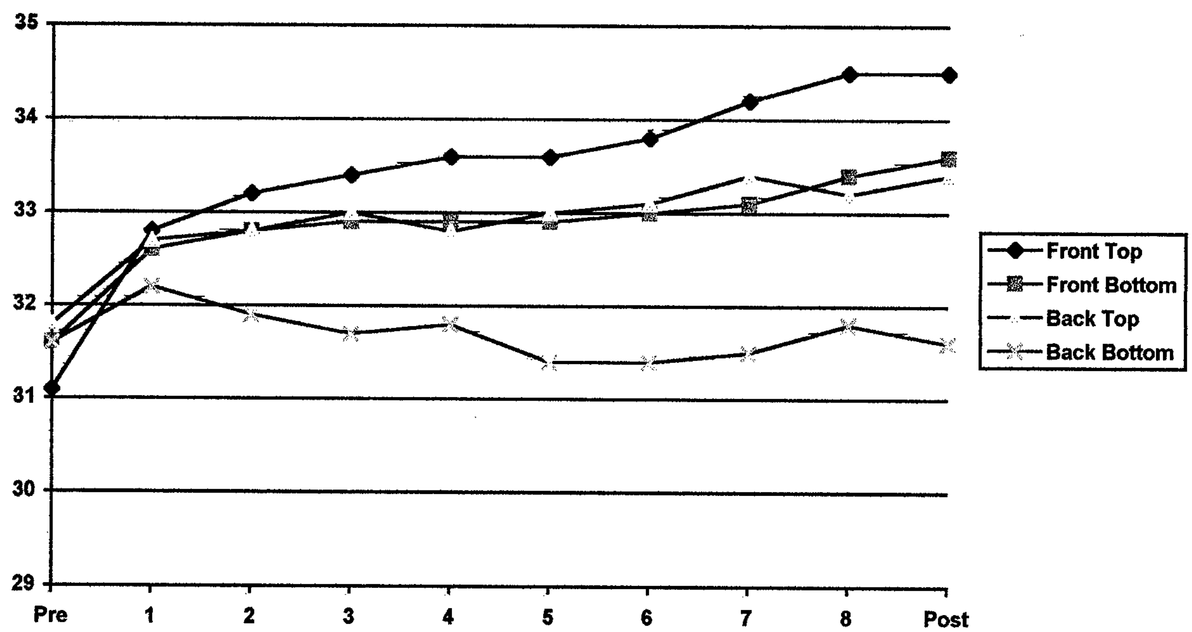


Fig. 6 Mean Skin Temperature

An ANOVA of skin temperature comparing differences between the four litter positions was completed, refer to Table 12, Skin Temperature Between Litter Positions ANOVA and significant differences were identified at inflight 3, p= 0.006, and continued through inflight 8 and postflight, p= 0.

	F	p
Pre flight	0.282	0.838
Inflight 1	0.606	0.616
Inflight 2	2.065	0.126
Inflight 3	5.083	0.006
Inflight 4	3.613	0.024
Inflight 5	9.624	0
Inflight 6	7.007	0.001
Inflight 7	8.884	0.001
Inflight 8	5.545	0.009
Postflight	10.251	0

Table 12 Skin Temperature Between Litter Positions ANOVA

Duncan post hoc testing was completed for inflight 3 through 8 and post flight readings, refer to Table 13, Skin Temperature Duncan. Skin temperature in the front/top litter position was significantly higher than skin temperature for subjects in the back/bottom litter position.

	Front/Top	Back/Bottom
Inflight 3	33.4°C	31.7°C
Inflight 4	33.6°C	31.8°C
Inflight 5	33.6°C	31.4°C
Inflight 6	33.8°C	31.4°C
Inflight 7	34.2°C	31.5°C
Inflight 8	34.5°C	31.8°C
Postflight	34.5°C	31.6°C

Table 13 Skin Temperature Duncan

Data related to study questions #4 and #5 are presented:

Question #4.) What is the relationship between litter ambient air temperature and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

Question #5.) What is the relationship between litter air flow and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

Correlation of ambient air temperature and the air flow to thermal perception, comfort perception, tympanic temperature, and skin temperature were completed by Pearson correlation. Refer to Table 14, Pearson Correlation of Median Air Temperature, and table 15, Pearson Correlation of Median Air Flow. Each subject's medians for ambient air temperature, air flow, thermal perception, comfort perception, tympanic temperature, and skin temperature were calculated. The all the medians for each identified variable were used for the Pearson Correlation. A significant correlation was noted between ambient air temperature and thermal perception ($p = 0.005$), tympanic temperature ($p = 0.024$), and skin

temperature (p = 0.004). Air flow is significant correlated with thermal perception (p = - 0.002).

	Median Temp. Perception	Median Comfort Perception	Median Tympanic Temp.	Median Skin Temp.
Correlation	0.467**	0.329	0.388*	0.482**
p =	0.005	0.057	0.024	0.004

** Correlation is significant at the 0.01 level (2 tailed).
* Correlation is significant at the 0.05 level (2 tailed).

Table 14 Pearson Correlation of Median Air Temperature

	Median Temp. Perception	Median Comfort Perception	Median Temp Tympanic	Median Temp. Skin
Correlation	- 0.503**	- 0.299	- 0.051	- 0.210
p =	0.002	0.086	0.775	0.234

** Correlation is significant at the 0.01 level (2 tailed).
* Correlation is significant at the 0.05 level (2 tailed).

Table 15 Pearson Correlation of Median Air Flow

<u>Limitations</u>

A number of limitations are evident in this research. First, the study is descriptive and did not attempt to control aeromedical operations thus, departure times, flight duration, aircraft model, and aircraft configuration were not controlled. Each of these variables could have potentially effected the data obtained. Variation in departure times may have affected subject's circadian rhythm and significantly impact an individual's set point thus, skewing data. Differences in flight duration did not allow for analysis of data beyond the two hour point as sufficient number of data were not available. Thus, this research is applicable only

to C-130 flights of short duration with low cabin altitudes, 2000 feet or below. A variety of aircraft models were used over the course of the study and it is not clear if there are significant differences between aircraft models and/or the year they were manufactured. Finally, aircraft configurations did not remain constant between flights. It is not known if the ambient air temperature and air flow are altered as a result of varying configurations within the cabin.

Second, instrumentation utilized in the study provided limitations. A limited number of instruments were available to collect data. Thus, continuous data collection was not possible nor were readings from litter positions simultaneously collected. Furthermore, the thermo-anemometer may require additional time than indicated in the literature to provide accurate ambient air temperature readings for colder temperatures. The thermo-anemometer can measure the air flow in a single direction. In this study, the air flow was measured from the front of the litter to the rear of the litter and air flow from above or the side of the litter was not measured. As a result, the ambient air temperature and air flow differences could be more significant than reported in this study. The tympanic and skin temperature probes must also be considered. Both probes were placed by the subjects thus, proper placement could be questioned even though the researcher did not identify any difficulty. However, the tympanic temperature probe was frequently subjected to movement over the duration of the flight while the skin temperature probes were not. The tympanic temperature probes may require more than the three minutes recommended by the manufacture in extreme weather condition in order to obtain an accurate reading.

The third major limitation is the sample. The sample size for this study was very limited. A number of flying squadrons were used to obtain data yet, the number of subjects from each unit was not uniform. The study's homogeneous sample of military aeromedical personnel decreases the external validity of the research to the general population. However, the data obtained from aeromedical personnel may be generalized to military personnel likely to be transported via Hercules C-130. Yet, the subjects were all in good health while actual patients may be more adversely effected by the inflight conditions. Thus, results of the study can generalized only to a healthy population. Moreover, blankets were not available to subjects as they would be to actual patients. This would effect responses and perception of the inflight environment by subjects.

Timing of data collected could potentially limit the study. Data collection was conducted only in winter months in the southern U.S. It is not clear whether similar results would be obtained in northern bases in the same time period. Furthermore, it is questionable whether thermal and comfort perceptions alter according to seasonal variation of temperature. Finally, the number of statistical test conducted on data may be considered a limitation. As the number of statistical test increases the likelihood that a false positive may be obtained also increases.

CHAPTER V DISCUSSION

The demographic data lends support to the idea that the sample was homogenic across litter positions. The results did not indicate any significance difference between litter positions for age, gender, height, weight or body mass index. The subjects in the litter positions were comparable. Information presented regarding the aircraft are descriptive in nature and indicates that a large variety of C-130 aircraft were utilized for aeromedical evacuation missions in this study.

Question #1.) To what extent do ambient air temperature and air flow at four litter positions change over time during aeromedical evacuation in a C-130?

Question #2.) Are there differences in average ambient air temperature and air flow at each litter position in different locations within the cargo compartment of a C-130 during aeromedical evacuation?

Ambient Air Temperature

It is evident from Figure 1, Mean Ambient Air Temperature, that the preflight temperatures in this study were lower than the inflight ambient air temperatures. The low preflight temperature was directly related to the flightline environment indicating that aeromedical evacuation aircrews must consider ambient air temperature conditions to appropriately care for their patients. The C-130 is a tactical aircraft and options for care of patients maybe limited. This research seems to indicate that procuring heating units in a cool environment is prudent when they are available. Note that this study did not focus on preflight data and it is not known at what point ambient air heating units would be

beneficial for patients. If heating units are not available during preflight, other measures like extra blankets should be considered.

A review of Figure 1, Mean Ambient Air Temperature, also illustrates how quickly the inflight ambient air temperature was stabilized inflight. It illustrates the ambient air temperature for the front/top litter position is consistently warmer than the ambient air temperature of the back/bottom litter position. However, referring to Table 1, Ambient Air Temperature Between Litter Positions ANOVA, statistical analysis of the data demonstrated a significant difference between the litter positions ($p=0.034$), only for the eighth inflight reading. Repeated measures ANOVA for location did approach significance ($p= 0.054$), indicating the front/top position was warmer than the back/bottom position.

There are a number of reasons why significant differences of ambient air temperature between the litter positions was not evident at more inflight periods. First, more data over a longer period of time may be required to demonstrate a significance and the limited sample size may have influenced the results obtained. Secondly, the aircraft may effect results, as a wide range of aircraft models and years of manufacture were used in the study. Ambient air temperature in the C-130 was controlled in the flight compartment. Crew members in the cargo compartment can influence the adjustments of the ambient air temperature. In this study, data were not collected regarding the comfort of the crewmembers not participating in the study. These crewmembers may have influenced the cargo compartment ambient air temperature and contribute to the results obtained.

The actual process of collecting data may have affected ambient air temperature results. Ambient air temperature was obtained in the center of the litter. It was noted on the

second flight that ambient air temperature in the litter position did not appear to be consistent. The researcher attempted to obtain data on this observation by obtaining ambient air temperature reading from the head, middle, and foot of the litter. The timing of this data collection was not consistent. These data are presented in Table 2, Random Ambient Air Temperature Readings Front/Top Litters, Table 3 Random Ambient Air Temperature Readings Front/Bottom Litters, Table 4, Random Ambient Air Temperature Readings Back/Top Litters, and Table 5 Random Ambient Air Temperature Readings Back/Bottom Litters. The random readings of ambient air temperature at the head, middle and foot of a litter position provides some interesting data. First, one must consider the sequence of data collection. The ambient air temperature at the middle of the litter reading was always collected prior to the head or foot readings. In Table 2, Random Ambient Air Temperature Readings Front/Top Litters, the head and foot readings are higher than the middle readings a 100% of the time. On the other hand, in Table 5, Random Ambient Air Temperature Readings Back/Bottom Litters, the ambient air temperature readings of the head and/or foot of the litter are colder than the middle readings 7 out of 8 times, 87.5% of the time. Also, note that the variation between the head and/or foot compared to the middle can be as great as 5.4°C in the back/bottom litter. This leads one to question the accuracy of the first ambient air temperature readings. The middle ambient air temperature was always obtained prior to the other two readings. It is possible that the instrument required addition time to obtain an accurate reading in cold environments. Thus, the reading from the head and foot positions of the litter may be more accurate as they were obtained following the middle reading allowing the instrument additional time to fall or rise obtaining an accurate

reading. However, if one were confident that the ambient air temperatures were accurate then a single reading to obtain ambient air temperature for litters is not suitable. In this scenario obtaining a number of ambient air temperature readings for a litter position may be more appropriate. If one reading for ambient air temperature were desired then it may be more appropriate to obtain a head reading as the body is typically covered while subjects' and patients' heads are not covered.

Air Flow

The air flow in this study did not consistently demonstrate significance between the litter positions, refer to Table 6, Air Flow Between Litter Positions ANOVA. A review of Figure 2, Mean Air Flow, demonstrates that air flow appeared to vary. The researcher's confidence in air flow data is restrained. The instrument that measured air flow was selected to measure the air flow across the litter from the foot of the litter to the head of the litter or from the front to the back of the aircraft. The researcher noted that air flow in the C-130 was more complex than initially anticipated. Indeed while the researcher was holding the thermo-anemometer probe air could be felt moving yet, the instrument indicated zero air flow. It was evident that the air flow was more turbulent and struck the individual from not only the front to the back of the aircraft but also from the top and possibly from the side. It is recommended upon replication of the study to obtain air flow readings from additional aspects to include front to back, top to bottom, and from the sides. It may also be prudent to select another instrument that is able to detect air flow from a wider range.

Question #3.) To what extent do core temperature, skin temperature, thermal perception and thermal comfort of individuals in litter positions change over time during aeromedical evacuation in a C-130?

Thermal Perception

To discuss the results of thermal perception recall thermal perception indicated how hot or cold the ambient air temperature felt to the subject. Hot and cold were at opposite ends of the visual scale and scoring cold = 0 and hot = 10. Thus, the higher the number indicated the warmer the ambient air temperature felt to the subject and vise versa the lower the number the colder the ambient air temperature felt to the subject. Reviewing Figure 3, Mean Score for Thermal Perception, clearly demonstrates the front/top litter position consistently felt warmer than the back/bottom litter position to the subjects. The specific degree of significance between litter positions is reported in Table 7. Thermal Perception Between Litter Positions ANOVA. It is interesting to note how quickly a significant difference was evident between the litter positions, starting at the second inflight reading ($p=0$) and continued through postflight readings (p = range 0-0.03). The Duncan post hoc testing, Table 8, confirmed that the thermal perception score for the front/top litter position was significantly higher than the thermal perception score for the back/bottom litter position.

One may consider the discrepancy between ambient air temperature readings and thermal perception readings to present difficulty for the study. There are a number of reasons why a significant difference in ambient air temperature was not obtained between litter positions while strong, and consistent statistical significant differences between litter

positions exist for thermal perception. First, recall from Figure 1, Mean Ambient Air Temperature, that the front/top litter was consistently warmer than the back/bottom. Although this difference was not considered significant by the ANOVA in Table 1, Ambient Air Temperature Between Litter Positions ANOVA, it appears to be significant to individual's perception of ambient air temperature. It may mean that only slight variations in ambient air temperature are perceived by individuals in the inflight environment. Another possibility may be attributed to the inflight environment. Some research indicates that at higher altitudes individuals perceive that the ambient air temperature is colder than they perceived the same ambient air temperature at a lower altitudes (Blatteis & Lutherer, 1976). The final possibility involves the instrumentation. It has been discussed that the instrument measuring ambient air temperature may not have been permitted sufficient time to fall or rise to the accurate temperature thus, a significant difference may be present and, a discrepancy may not exist.

Finally, one must consider if the significant difference of thermal perception between the front/top and back/bottom litter positions is meaningful. Pondering the gravity of the variation one must refer to Table 8, Thermal Perception Duncan. Note that the variance between the two litter positions is almost 3 points on a 10 point scale. The perception of the ambient air temperature was a valuable reading because the body's perception of the environment triggers body adaptation to that environment. Thus, with a cold environment the body attempts to generate and conserve body heat. When the body perceived a cold environment it was stressed to maintain its core temperature. The degree of stress is influenced by the degree of temperature variation.

Comfort Perception

The comfort perception instrument asked subjects to determine how comfortable or uncomfortable they are with the perceived ambient air temperature. For comfort perception intense discomfort measures =0 and, at the opposite end of the visual scale, extreme comfort =10. Thus, the higher the comfort perception score the more comfortable the subject felt. Refer to Figure 4, Mean Score for Comfort Perception, for specific comfort perception results. It was clear that subjects in the front/top litter position were more comfortable than those in the back/bottom litter position. The significance of the difference between the litter positions of comfort perception was presented on Table 9, Comfort Perception Between Litter Positions ANOVA. It indicates a significant difference between the litter positions occurred rapidly, by the third inflight reading, and continued through the eighth inflight reading. The Duncan post hoc test, Table 10, indicated the perceived comfort score for subjects in the front/top litter position was greater than the perceived comfort level of the back/bottom litter position.

It is not surprising that the comfort perception results are similar to the thermal perceptions results. Why do both perception scales indicate that the front/top litter position was warmer and more comfortable with higher scores than the colder uncomfortable back/bottom litter position? The rational for the front/top position comfort perception score being higher is most likely attributed to its proximity to the heating vent that is located above the position. The lower temperature and comfort score for the back/bottom litter may be affected by its proximity to the ramp of the aircraft. Thus, for the winter months subjects were more comfortable in a perceived warmer inflight environment of the front/top position.

Finally, the degree of variation between the litter positions needs to be addressed. The average variation between the comfort perception of the front/top litter position and back/bottom litter position was more than 3.5°C. Again the variation indicates that the subjects in the back/bottom litter positions are more stressed by the thermal environment than subjects in the front/top litter position. For flight nurses the variation of the comfort perception needs to be kept in mind for patients who are not able to indicate discomfort related to the thermal environment. The crew may need to take proactive actions to maintain comfort and decrease possible thermal stress. However, interventions in this environment need to be investigated.

Tympanic Temperature

Data presented in Figure 5, Mean Tympanic Temperature, indicates preflight tympanic temperature reading were very low, inflight readings were higher than preflight and did not appear to vary greatly. The preflight tympanic temperature was extremely low regardless of the litter position. In fact, the preflight tympanic temperatures were below 35°C, which is considered hypothermic. The low initial tympanic temperature may possibly be related to the timing of the preflight data collection. Tympanic temperature probes may not have been in place for three minutes prior to obtaining the preflight reading as recommended by the manufacturer. The tympanic temperature probes were placed by the subjects when they were placed on the litter. In the rush to obtain data prior to take off an accurate baseline reading may not have been obtained. Another possibility is that the three minute wait period may not be sufficient in the cold preflight environment. It is probable

that the low preflight tympanic temperature readings are attributable to an equipment difficulty as the readings were below the skin temperature readings noted in Figure 6, Mean Skin Temperature.

Now focus will shift to the inflight tympanic temperature readings. No significance was noted between litter positions seen in Table 11, Tympanic Temperature Between Litter Positions ANOVA, and readings were remarkably similar for the duration of the flight. Such consistency is not surprising as the body's goal was to maintain homeostasis and preserve core temperature. Thus, even with individuals perceiving the back/bottom litter position as colder and more uncomfortable than the front/top litter position yet, all subjects maintained a stable core temperature over the course of the flight. Although the temperatures were consistent throughout the inflight period they are also low. The inflight mean tympanic temperatures ranged from 34°C to 35.8°C, below 35°C is considered hypothermic. The percentage of inflight means above 35°C for the litter positions were as follows: front/top 87.5%, front/bottom 100%, back/top 50%, and back/bottom 87.5%. It is difficult to comprehend there could be high numbers of individuals were hypothermic inflight in front/top and back/top litter positions that do not have significantly low thermal or comfort perception scores. It is more probable that the instrument was not accurately reading the tympanic temperature. It is possible that the inflight environment may effect its measurement. Furthermore, the tympanic temperature probes were placed by the subjects. Accurate readings are dependent on proper placement and probe placement may have shifted during flight.

Skin Temperature

Skin temperature readings for the four litter positions varied greatly from tympanic temperature reading, Figure 6, Mean Skin Temperature. It is evident skin temperatures for subjects in the front/top litter position were higher than the skin temperatures for the back/bottom litter position. Significant differences between the litter positions was established swiftly inflight, by the second inflight reading, and continued through the postflight reading. The Duncan post hoc test, Table 13, Skin Temperature Duncan, validated that the skin temperatures for subjects in the front/top litter position were significantly higher than skin temperatures for subjects in the back/bottom litter position.

Subjects in the back/bottom litter positions perceived that the ambient air temperature was cooler and were more uncomfortable. Thus, their bodies were stressed by the thermal environment to maintain their core body temperature, as measured as tympanic temperature, by vasoconstriction to decrease blood flow to the skin allowing skin temperature to fall. In the front/top litter position subjects were not as stressed to maintain core temperature and the skin temperature did not fall in fact, they were warm and skin temperature rose over the course of the flight following the initial exposure to the cold preflight environment.

Question #4.) What is the relationship between litter ambient air temperature and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

Question #5.) What is the relationship between litter air flow and individual's core temperature, skin temperature, thermal perception, and thermal comfort in litter positions during aeromedical evacuation in a C-130?

The Pearson correlation of median air temperature yield interesting results. As noted previously, significant differences between litter positions was not clearly evident in the flight environment. However, there is a significant correlation between the ambient air temperature and thermal perception, tympanic temperature, and skin temperature. As ambient air temperature increased so did the thermal perception scores, tympanic temperature, and skin temperature readings. Conversely, air flow was significantly negatively correlated to thermal perception. As the air flow increased the thermal perception score fell and the subject perceived that the air temperature was colder.

Recommendations

Recommendations from evaluating of this study can be divided into practice and additional research concerns. Regarding practice recommendations, this study should be used to heighten aeromedical crewmembers concern regarding thermal stress onboard the C-130 aircraft. Secondly, this study can aid crewmembers to understand the variation of temperature in the litter position and anticipate where temperature may negatively impact on patients. True, healthy subjects in this study did not have any difficulty maintaining a stable core temperature yet, a compromised patient combating the other stresses of flight many not be so successful.

Specific practice measures may require closer scrutiny. First, aircrew members need to assess the need for portable heating units during preflight operations when ambient air

temperatures are cool. Second, involves patient positioning onboard the aircraft. The litters on the C-130 aircraft are secured to the stanchions by straps attached to the ceiling and fall to the floor. Thus, litters must be loaded in a specific sequence forward stanchions before rear stanchions and top positions prior to lower positions. Conversely to off load litters on the C-130 the lowest litters are removed first and the rear stanchions are cleared first. As a result, the most critical patients are loaded last to ensure they are deplaned first. It also means that the most critically ill patients are located in the back/bottom litter position. This study indicates however, that the back/bottom litter position likely imposes the greatest thermal stresses on an individual. Crewmembers must keep both concerns in mind when determining appropriate patient placement.

Additional studies regarding the thermal environment onboard the Hercules C-130 must be completed before change in practice can be implemented. The present study needs to be replicated using a larger sample size during different seasons of the year, in a variety of geographical locations. Future studies also need to evaluate the thermal environment of additional litter positions in the aircraft. It is recommended that thermal studies be conducted on actual patients transported onboard C-130 aircraft. This would be difficult as the C-130 aircraft are not typically utilized for routine patient movement. Finally, interventions to combat thermal stresses in the inflight environment are required.

If replication of this particular study is undertaken, concern needs to be placed on the instruments used for data collection. If the same instruments are to be utilized, it is suggested the thermo-anemometer be allowed a longer period of time to obtain ambient air temperature readings. Consider using multiple reading to obtain the litter ambient air

temperature and that multiple directions be used to collect air flow data. Inflight thermal studies to improve care for actual patients transport on Hercules C-130 are required. Regarding the tympanic temperature probe the researcher might consider observing subject placement prior to obtaining each reading.

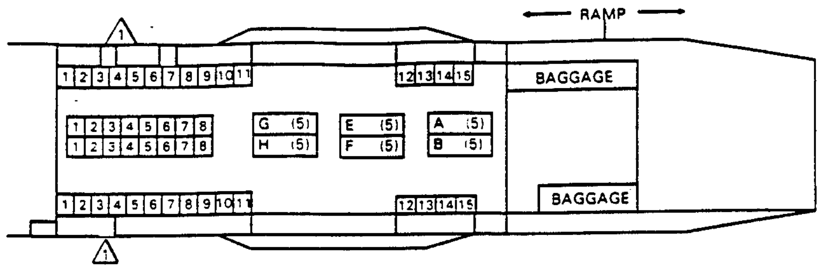
Finally, additional studies to identify extraneous variables affecting thermoregulation inflight are required. Despite the identified limitations of the study, the information on the inflight litter thermal environment measures and human perceptions of that environment are needed by flight nurses. This study can aid flight nurses to determine appropriate litter placement within the cabin of patients at increased risk to thermal stress of flight.

APPENDIX A

AF Form 3905

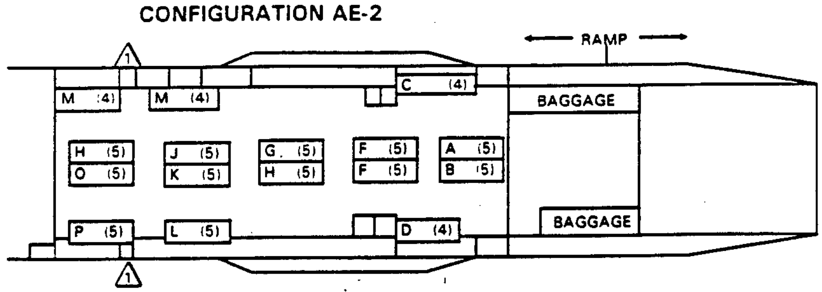
30 Litters/
46 Seats

CONFIGURATION AE-1



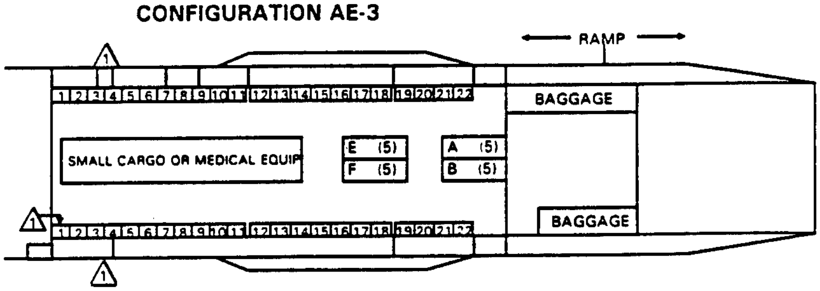
68 - 76 Litters/
8 Wheel Well Seats

CONFIGURATION AE-2



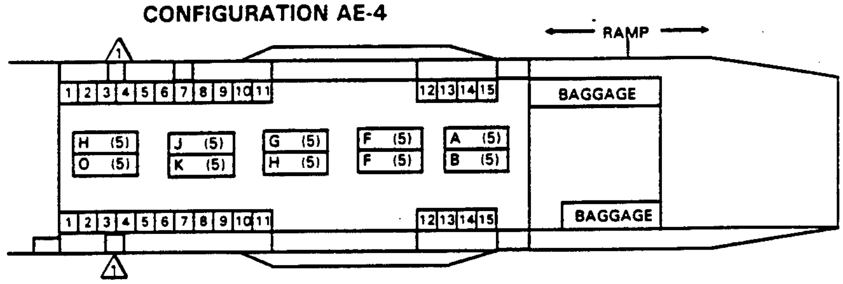
20 Litters/
44 Seats

CONFIGURATION AE-3



50 Litters/
30 Seats

CONFIGURATION AE-4



NOTES 1. ☐ GROUND ESCAPE EXITS
2. △ AIRCRAFT 83-0486 AND UP

APPENDIX B

Visual Analog Data Sheet

Identification # ______________ Date ______________

Flight # __________ Litter Position __________

Instructions On the first line, labeled thermal perception, put a mark that best describes how hot or cold you are at that particular time. On the second line, labeled thermal comfort, put a mark that best describes your thermal comfort at that particular time. You will be asked to evaluate thermal perception and thermal comfort prior to take off, every 15 minutes inflight and upon landing. Each time you are asked to complete the data sheet indicate your perception of hot/cold and comfort at that exact time. Previous assessment are available to you to compare to your present perceptions.

Pre flight
Time __________

Thermal Perception

Hot ____ Cold

Thermal Comfort

intense discomfort ____ extreme comfort

Inflight
Time __________

Thermal Perception

Hot ____ Cold

Thermal Comfort

intense discomfort ____ extreme comfort

Time __________

Thermal Perception

Hot ____ Cold

Thermal Comfort

intense discomfort ____ extreme comfort

APPENDIX C

SGO #
ARMY/AIR FORCE CONSENT FORM

Thermal Environment of Litter Positions and Human Thermal Perceptions Onboard Hercules C130 Aircraft

PURPOSE AND DURATION OF STUDY:
I volunteer to participate as a test subject in this research study. The purpose of this study is to measure the air temperature, air movement, human temperature response and human comfort level during aircraft transportation.
This study will enroll 80 subjects at 433 AES, Kelly Air Force Base over a period of 6 months, and will require that I wear special clothing, lay flat on a NATO litter for flight duration, have my temperature checked every 15 minutes, and complete a survey of my comfort level every 15 minutes. I understand I was selected to participate in this study because I am part of the regularly scheduled Air Force Reserve flight crew.

PROCEDURES:
As a participant, I understand that I will undergo the following procedures:
I will wear special clothing, a flightsuit, lay flat on a NATO litter for duration of the flight, usually two to four hours, have my temperature checked every 15 minutes, and complete a survey of my comfort level every 15 minutes. I will wear four skin temperature probes and one tympanic temperature probe. Skin temperature probes are one inch in diameter, made of form and remain in position by an adhesive surface. One skin temperature probe will be placed on the chest, bicep, thigh, and calf. A tympanic temperature probe will be placed in your ear and resembles and ear plug.

RISKS OR DISCOMFORTS:
There is no risk or discomfort associated with this study.

BENEFITS:

I understand that there is no guarantee I will receive any benefit from this study other than knowing that the information may help future patients.

ALTERNATIVE TREATMENT:

I understand that choosing not to participate in this study is the alternative to volunteering for the study.

CONFIDENTIALITY OF RECORDS OF STUDY PARTICIPATION:
Records of my participation in this study may only be disclosed in accordance with federal law, including the Federal Privacy Act, 5 U.S.C. 552a, and its implementing regulation. DD Form 2005, Privacy Act Statement-Health Care Records, contains the Privacy Act Statement for the records. I understand that signing this document I give my permission for information gained from my participation in this study to be published in medical literature, discussed for educational purposes and used generally to further medical science. I understand that I will not be personally identified; all information will be presented as grouped data.

I understand that my records may be reviewed by WHMC Institutional Review Board, U.S. Food & Drug Administration (FDA), and other government agencies.

I understand complete confidentiality cannot be promised, particularly for military personnel, because information bearing on my health may be required to be reported to appropriate medical or command authorities.

ENTITLEMENT TO CARE:
I understand that my entitlement to medical and dental care and/or compensation in the event of injury are governed by federal laws and regulations, and if I have questions about my rights or if I believe I have received a research-related injury. I may contact the Wilford Hall Medical Center Patient Representative, 210-292-6688, and/or Major Erickson, 210-292-6779. I understand that participation in this study does not alter my ongoing medical benefits as a military beneficiary, and I will continue to receive any needed medical treatment should I experience illness or injury as a result of this study. In the event of physical injury resulting from the investigational procedures, the extent of medical care provided is limited and will be within the scope authorized for DoD health care beneficiaries. Needed medical treatment does not include domiciliary (home or nursing) care.

GOOD FAITH NOTIFICATION:
I understand that you cannot guarantee or promise that I will receive benefits from this study; however, I understand you will undertake your best efforts to keep me informed of any adverse complications which may result from my participation in this study.

VOLUNTARY PARTICIPATION:
The decision to participate in this study is completely voluntary on my part. No one has coerced or intimidated me into participating in this project. I am participating because I want to. Major Erickson has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that Major Erickson will be available to answer any questions concerning procedures throughout this study. I understand that if significant new findings develop during the course of this study which may relate to my decision to continue participation, I will be informed. I further understand that I may withdraw this consent at any time and discontinue further participation in this study without prejudice to my entitlements to care. Should I choose to withdraw, my condition will continue to be treated in accordance with acceptable standards of medical treatment. I also understand that the investigator of this study may terminate my participation in this study at any time if he/she feels this to be in my best interest.

I voluntarily consent to participate in this study. All oral and written information and discussions about this study are in English, a language in which I am fluent.

A copy of this form has been given to me.

____
VOLUNTEER'S NAME AND BRANCH OF SERVICE (Typed or Printed)

____________________	____-____-____	____-____-____	________
VOLUNTEER'S SIGNATURE	**VOLUNTEER'S SSN**	**SPONSOR'S SSN**	**DATE**

(If the subject is a minor and in the opinion of the attending physician, the minor can understand the nature and consequences of participation in the study, the minor should sign above. If the minor is determined to be able to understand but is unable to sign, the advising investigator will indicate the minor has orally assented to participate in the study by placing the investigator's initials here: _______)

____
PARENT'S OR GUARDIAN'S NAME (Typed or Printed)

____________________	____-____-____	________
PARENT'S OR GUARDIAN'S SIGNATURE	**SSN**	**DATE**

____
PARENT'S OR GUARDIAN'S NAME (Typed or Printed)

____________________	____-____-____	________
PARENT'S OR GUARDIAN'S SIGNATURE	**SSN**	**DATE**

(Generally, both parents or guardians will sign if minor subjects are involved. For clinical investigation categories described by AFI 40-403, para 4e(3) or (4), both parents or guardians must sign unless one is deceased, unknown, incompetent, not reasonably available, or only one parent or guardian has legal responsibility for the care and custody of the minor.)

____
ADVISING INVESTIGATOR'S NAME (Typed or Printed)

____________________	____-____-____	________
ADVISING INVESTIGATOR'S SIGNATURE	**SSN**	**DATE**

(Can only be signed by principal or associate investigators.)

____
WITNESS' NAME (Typed or Printed)

____________________	____-____-____	________
WITNESS' SIGNATURE	**SSN**	**DATE**

(Must witness ALL signatures above)

TITLE OF STUDY: Thermal Environment of Litter Positions and Human Thermal Perceptions Onboard Hercules C130 Aircraft

Protocol #:

Date Protocol Approved by WHMC/BAMC IRB:

Atch

Distribution:
White: HSRP
Lt yellow: Medical Record
Pink: PI
Dk yellow: Subject

____
Subject's Stamp Plate

PRIVACY ACT OF 1974 APPLIES.
DD FORM 2005 FILED IN CLINICAL /MEDICAL RECORDS

APPENDIX D

Demographic Data Sheet

Identification Number ___________ Date ________________

Age ____________

Gender Male Female

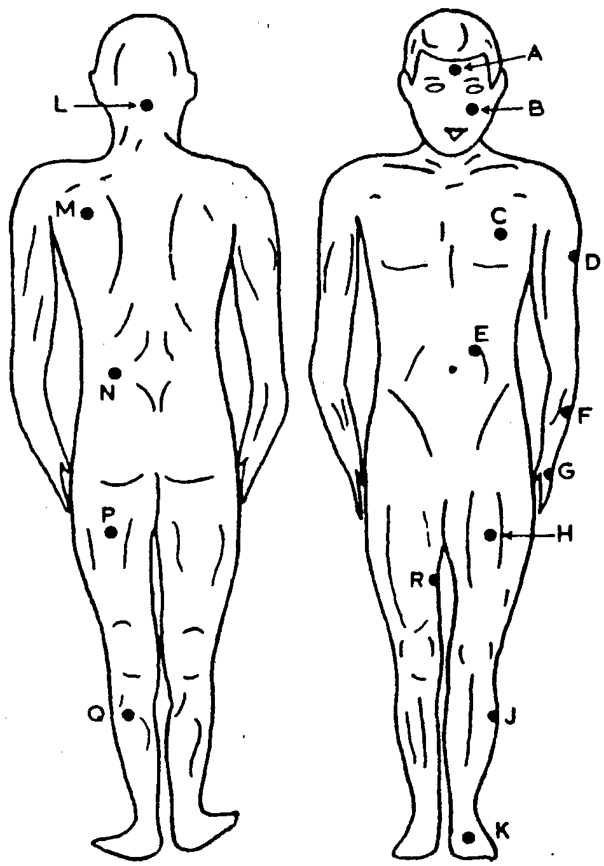
Height ____________ inches

Weight _____________ lb.

APPENDIX E

Skin temperature probe placement picture for subjects (Mitchell & Wyndham, 1969).

Placement sites for this study encluded: C, D, H, and J.



APPENDIX F

Temperature Data Sheet

Identification # ________________ Date ________________

Flight # ___________ Litter Position ___________

Pre flight	Air temp. __________	Tympanic __________
Time	Air flow ___________	Chest ______________
__________		Biceps _____________
		Thigh ______________
		Calf ________________

Inflight	Air temp. __________	Tympanic __________
Time	Air flow ___________	Chest ______________
__________		Biceps _____________
		Thigh ______________
		Calf ________________

Time	Air temp. __________	Tympanic __________
__________	Air flow ___________	Chest ______________
		Biceps _____________
		Thigh ______________
		Calf ________________

APPENDIX G

Flight Information Data Sheet

Flight # __________ Date ___________

Aircraft model __________ Year manufactured __________

Aircraft tail # __________

Cabin altitude inflight __________

Take off time __________

Landing time __________

Flight time __________

Known aircraft equipment malfunctions related to thermal system:

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VITA

Margaret Mary Walsh was born June 23, 1963 in Green Bay, Wisconsin, the sixth of seven children to Richard and Mary Ann Walsh. She attended Saint Joseph's Academy, graduating with academic honors in 1981.

Attending the University of Southern California, in Los Angeles, California, Miss Walsh earned a baccalaureate degree in nursing, graduating with academic honors in 1986. She has completed numerous military education courses to include: Internship program, Nurse Service Management, Flight Nurse program and Squadron Officer School.

Miss Walsh began her nursing career as a staff nurse , orthopedic unit, at California Medical Center, Los Angeles, California. In 1987, she entered active duty service in the U.S. Air Force, were she continues to serve. Military service has provided a variety of practice arenas for Miss Walsh to include: general surgery, adult special care unit, obstetrics, and flight nursing. Her assignment locations has been as diverse: California, Japan, Germany, and Texas. She has been awarded the Air Force Commendation Medal with two oak leaf clusters.

Miss Walsh has been selected for the rank of major and will assume a nurse manager position at Little Rock Air Force Base, Arkansas, at the completion of her masters program